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Vol. 237 JANUARY, 1944 No. 1

HISTORICAL NOTES ON THE DETERMINATION OF DISTANCE BY TIMED RADIO WAVES.

BY
C. D. TUSKA.

INTRODUCTION.

One of the important uses of radio waves is in the determination of distance. Distances have been determined radiowise by triangulation, by observations employing radio time signals, and by measurements of the time required for radio waves to travel between two points. These notes deal especially with the historical aspects of the methods and of the apparatus used in such measurements.

Since some of the earliest reported measurements of distance by timed radio waves were inspired by the desire to obtain evidence of the existence of the Heaviside-Kennelly Layer, it seems proper to review briefly the early theories of "the layer" before describing the methods and apparatus. The first direct evidence was obtained by Appleton and Barnett,[1] who used a system employing frequency modulated waves; almost at the same time Breit and Tuve,[2] who devised a method utilizing pulses of radio energy, succeeded in their efforts to reflect waves from the ionized regions. Although the apparatus has been much improved, the frequency modulation and pulse methods are the basis of the modern systems. The development of the art will be traced through technical publications and United States Patents.

THE KENNELLY-HEAVISIDE LAYER.

On December 12, 1901, Marconi received signals which had been transmitted from Poldhu, Cornwall, to St. Johns, Newfoundland.[3] The transmitting antenna was not over 150 feet in height; the receiving antenna was a wire 400 feet long supported by a kite. The signals were received notwithstanding the fact that the rotundity of the earth

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amounted to an elevation of over 100 miles in the approximately 2,000 miles between the transmitting and receiving antennas.

The scientists of that day sought a theory, which would explain how the waves got over the protuberance between Poldhu and St. Johns. The theory came quickly and almost simultaneously from Professor A. E. Kennelly [4] in the United States and independently from Oliver Heaviside [5] in England. While Erskine-Murray,[6] Fleming,[7] and Zenneck,[8] respectively, have credited the theory to Fitzgerald,[9] Dewar,[10] and Blondel,[11] respectively, we shall accept the current opinion that Kennelly and Heaviside were the originators of the ionized layer theory in its application to long distance electromagnetic wave propagation. For convenience the term Kennelly-Heaviside Layer will be abbreviated to KHL, and we shall resort to Kennelly's original words for his concept of the layer.

"ON THE ELEVATION OF THE ELECTRICALLY-CONDUCTING STRATA OF THE EARTH'S ATMOSPHERE."*

"BY A. E. KENNELLY.

"According to the measurements of Professor J. J. Thomson ('Recent Researches in Electricity and Magnetism,' p. 101), air at a pressure of 1–100 mm. of mercury has a conductivity for alternating currents approximately equal to that of a 25 per cent. aqueous solution of sulphuric acid. The latter is known to be roughly 1 mho-per-centimeter, so that a centimeter cube would have a resistance of about one ohm. Consequently, air at ordinary temperatures, and at a rarefaction 76,000 times greater than that at sea level, has a conductivity some 20 times greater than that of ocean water, although about 600,000 times less than that of copper.

"If we apply the ordinary formula for finding the elevation corresponding to a given air-rarefaction, we find that if the air had a uniform temperature of 0 deg. C., the height of this stratum of air with a rarefaction of 76,000, would be

18.39 log 76,000 kilometers above the sea,
or 89.77 kilometers,
or 55.77 miles.

"If the air had a uniform temperature of − 50 degs. C. this elevation would be reduced 18.3 per cent., or to 73.3 kilometers (45.5 miles). The temperature of the earth's atmosphere has only been measured within a range of a very few kilometers above the surface of the sea, and consequently the materials are not at hand for any precise calculation of the height of electrically conducting strata. It may be safe to infer, however, that at an elevation of about 80 kilometers, or 50 miles, a rarefaction exists which, at ordinary temperatures, accompanies a conductivity to low-frequency alternating currents about 20 times as great as that of ocean water.

"There is well-known evidence that the waves of wireless telegraphy, propagated through the ether and atmosphere over the surface of the ocean, are reflected by that electrically-conducting surface. On waves that are transmitted but a few miles the upper conducting strata of the atmosphere may have but little influence. On waves that are transmitted, however, to distances that are large by comparison with 50 miles, it seems likely that the waves may also find an upper reflecting surface in the conducting rarefied strata of the air. It seems reasonable to infer that electromagnetic disturbances emitted from a wireless sending antennae spread horizontally outwards, and also upwards, until the conducting strata of the atmosphere are encountered, after which the waves will move horizontally outwards in a 50-mile layer between

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the electrically-reflecting surface of the ocean beneath, and an electrically-reflecting surface, or successive series of surfaces, in the rarefied air above.

"If this reasoning is correct, the curvature of the earth plays no significant part in the phenomena, and beyond a radius of, say, 100 miles from the transmitter, the waves are propagated with uniform attenuation cylindrically, as though in two-dimensional space. The problem of long-distance wireless wave transmission would then be reduced to the relatively simple condition of propagation in a plane, beyond a certain radius from the transmitting station. Outside this radius the voluminal energy of the waves would diminish in simple proportion to the distance, neglecting absorption losses at the upper and lower reflecting surfaces, so that at twice the distance the energy per square meter of wave front would be halved. In the absence of such an upper reflecting surface, the attenuation would be considerably greater. As soon as long-distance wireless waves come under the sway of accurate measurement, we may hope to find, from the observed attenuations, data for computing the electrical conditions of the upper atmosphere. If the attenuation is found to be nearly in simple proportion to the distance, it would seem that the existence of the upper reflecting-surface could be regarded as demonstrated."

The theory was not immediately accepted: In 1903 Lord Rayleigh [12] wanted an adequate explanation of the propagation of electric waves over long distances. In 1907 Erskine-Murray [6] recognized the probability of the KHL, but in 1910 Pierce [13] in considering daylight transmission was not entirely satisfied that an adequate explanation had been found. One of the difficulties was that some investigators thought the normal transmission was that obtained in daylight; others considered the transmission in darkness as the normal. The latter wanted a theory which would explain the "absorption during daylight transmission." They both sought a theory which would fit day and night transmission phenomena. The KHL theory was given a fresh start in 1912 by Eccles [14] who showed that the effective velocity of long electromagnetic waves increases at the higher levels of the middle atmosphere and that the long waves suffer "ionic refraction" and bend around the earth as they travel outwardly.

From 1912 through 1921 many papers were written about the KHL and other papers offered explanations of electromagnetic wave propagation in which the existence of the KHL was taken for granted. Errors in radiogoniometry were credited properly to the ionized layer. T. L. Eckersley [15] reported in 1921 his classic experiments in radio direction finding. He demonstrated conclusively that horizontal deviations of the waves would not explain direction finder errors. His carefully conducted experiments showed that night errors in radio direction finding could best be explained by the effects of a conductive layer in the upper atmosphere from which the waves might be reflected and might be abnormally polarized. While Eckersley's experiments went a long way toward establishing a reflective layer, they were not quite direct proof.

In 1924 Larmor [16] made a contribution to the KHL theory by showing that if even a very small proportion of the molecules of the upper air were ionized, so as to provide electrons or light ions, the electromagnetic waves of the usually employed wave-lengths would be bent

downwardly without undue absorption. The theory appears to have been completed in 1925 by Appleton [17] and independently by Nichols and Schelleng.[18] The complete theory takes into account the effect of the earth's magnetic field and the movements of the free electrons. Moreover these authors show that comparatively poor transmission of radio waves having a length of approximately 200 meters indicates a selective effect in the atmosphere. This selective effect is the result of the natural wave-length of vibration of free electrons in the earth's magnetic field. Finally the electric vector of a wave traveling parallel to the magnetic field is rotated; waves traveling perpendicular to the magnetic field undergo double refraction.

Since it is outside the scope of the present notes to go into the complex ionosphere theory, reference is made to the original papers and to the wealth of articles on the KHL. For our present purposes we can picture a hollow sphere composed of electrons and ions, probably of several layers, surrounding the earth. The layers are not constant but rise and fall, combine and separate, and appear to follow durinal and seasonal cycles; the layers are affected by sunspots and solar eclipses. For waves of different length, the layers behave differently: the longer waves are reflected; the shorter waves are refracted; and many of the waves are circularly or elliptically polarized in traveling through the ionized regions; and still other waves react upon the electrons and perhaps ions and set them into vibration thus the vibrating electrons may become secondary sources of radio waves. Is such vibration a belated and partial fulfillment of the prophecy of "the music of the spheres"? [19]

The challenge to learn more of the Kennelly-Heaviside Layer was not ignored. Smith-Rose and Barfield [20] attempted early in 1925 to measure the angle of waves reflected from the upper atmosphere but they concluded that their observations could not be relied upon because of the conductivity of the soil at the wave-length used in their observations. Later in 1925 they conducted further experiments [21] at a higher frequency but concluded, "the experiments cannot be considered as evidence for or against the existence of downcoming waves as required by the Heaviside Layer theory."

DIRECT EVIDENCE OF DOWNWARD ATMOSPHERIC REFLECTION OF RADIO WAVES MEASUREMENTS OF APPLETON AND BARNETT.

Appleton and Barnett [1] obtained direct evidence of downward reflection of radio waves and of the virtual distance of the reflecting layer in their experiments of December 11, 1924, and February 17, 1925. These experimenters started with the assumption that for wave-lengths of the order of 300–500 meters, a receiver located at about 100 miles from the transmitter will receive during darkness a direct wave and an indirect wave. If the two waves are of the same order of amplitude, pronounced interference effects may be expected. The theory was tested by varying

the wave-length of the unmodulated carrier of the British Broadcasting Corporation's Bournemouth Transmitter over a range of 5 to 10 meters at a uniform rate in a given time (e.g., 10 to 30 seconds), during which interval the antenna current remained substantially constant.

A four-stage high frequency amplifier, using a tuned-anode coupling with high resistance coupling coils to produce flat tuning, was installed at Oxford. An Einthoven galvanometer was connected to the receiver output. The expected interference phenomena, established by the varying wave-length and difference in path lengths, were observed by the maxima and minima of the galvanometer indications. In the case of a wave-length change of 385–392 meters, the average number of interference fringes was 4.5; a change of 385–395 meters produced 7.0 interference fringes.

Appleton and Barnett showed that if the direct wave path is a, and the indirect or reflected wave path is a', the reflected wave arrives N wave-lengths behind the direct wave, where $N = \frac{a' - a}{\lambda}$, λ being the wave-length. If N is an integer, the waves steadily reinforce; if N is half-way between two integers, the waves are steadily opposed in phase. If the wave-length is gradually increased to λ' at the transmitter, the number of signal maxima N to be expected is

$$(a' - a) = \left(\frac{1}{\lambda} - \frac{1}{\lambda'}\right) \quad \text{or} \quad \frac{\delta\lambda}{\lambda 2}(a' - a)$$

if the change in wave-length is small. Since δ and λ are known, the difference in path lengths $(a' - a)$ may be calculated. Substituting the two sets of observed values in the equation:

Case 1	*Case 2*
$\lambda = 385, \quad \delta\lambda = 7, \quad N = 4.5$	$\lambda = 385, \quad \delta\lambda = 10, \quad N = 7$
$4.5 = \frac{7(a' - a)}{(385)^2}$	$7 = \frac{10(a' - a)}{(385)^2}$
$a' - a = 95.5 +$ kilometers	$a' - a = 104 +$ kilometers

we find that the difference in path length is approximately equal to 100 kilometers, which indicates a virtual height of the KHL of the order of 80 kilometers, if the indirect wave went through a single reflection.

While the interference fringes demonstrated that the received signals traveled two paths, the experiment does not indicate whether the indirect path is horizontal or vertical. Furthermore, the difference in path lengths does not indicate if the waves went through one or more than one reflection. Appleton and Barnett conducted a second set of experiments to exclude the possibility of an indirect horizontal path and to check the altitude of the KHL from the angle of the downcoming

waves. Signals were received on a T antenna and on a large single turn loop antenna having its plane in the plane of propagation. The T antenna was substantially non-directive in the horizontal plane; the loop had a figure-of-eight horizontal direction pattern. The horizontal portion of the T was at right angles to the plane of propagation. Since the plane of the T bisected the plane of the loop, interaction was minimized. The two antennas were connected, respectively, to two high frequency amplifiers which were tuned to the same signals and were adjusted to produce the same galvanometer output readings in the daytime.

In the daytime, signals were received only over the direct path; at night, the signals came over a direct path and an indirect path. If the indirect path were horizontal, the loop signals should diminish, while the T antenna signals would be substantially unchanged. If the indirect path were inclined toward the vertical, the ratio of the loop signals to the T antenna signals should increase. A large number of observations of the ratios were made, using due care to observe the same signal maxima and minima, and invariably the ratio was greater than unity. The most frequently observed ratio was 2.85. It was shown that this ratio indicated a slope of about 69°, assuming a single atmospheric ray. Other observations were made using signals at a greater distance, e.g., 140 kilometers; these observations also showed consistently larger signals in the loop and a ratio of 1.5. The calculated angle was 48°, which was in accord with the greater distance, and in accord with a layer height of 80 to 100 kilometers. Thus was the height * of the Heaviside-Kennelly Layer first determined; it was of the order predicted by Kennelly!

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MEASUREMENTS OF BREIT AND TUVE.

Shortly after Appleton and Barnett made their first KHL measurements in England, Breit and Tuve [2] began their observations in the United States. The Breit and Tuve method consisted in radiating trains of continuous oscillations. The duration of each train was about 1/1,000 second. At the receiving station, the radiated waves were detected, amplified and oscillographed. If the waves followed a single path, the oscillogram showed a single set of humps. If the waves followed two paths, two or more sets of humps were shown. The displacement of the second hump from the initial hump is a measure of the retardation and hence the difference in path lengths.

* Appleton and Barnett also demonstrated, during the course of their experiments: (1) The atmospheric rays were generally elliptically polarized. This was in accord with Appleton's magneto-ionic theory of atmospheric refractions. (2) The elliptically polarized rays were sufficient to cause direction finder errors at distances of 30–50 miles over land. (3) The reflection coefficient of the ionized layer for low angles of incidence was shown to be between 0.2 per cent. and 6 per cent., according to the assumed attenuation factor for the ground wave. (4) The inferior limit for the number of electrons per cubic centimeter of the ionized layer was shown to be 10^5.

The first tests took place in the spring of 1925 at about 9 A.M., on wave-lengths of 600, 650, or 675 meters. The waves were transmitted from the Radio Corporation of America's Station WSC at Tuckerton, New Jersey. The pulses or wave trains were produced by means of a chopper in the grid circuit of a master oscillator. The pulse frequency was 600 per second. The receiver consisted of a superheterodyne whose second detector was connected to one set of deflecting plates of a Western Electric cathode ray oscillograph. The other set of deflecting plates was connected to an alternating potential of adjustable frequency. The cathode ray was also subjected to the influence of a magnetic field of the same adjustable frequency. This established an elliptical trace in which the signals produced deflections perpendicular to the major axis. The central portion of the trace gave a uniform time scale. The adjustable frequency of the order of 60 cycles per second was synchronized with a sub-multiple of the signal modulation so that the trace on the fluorescent screen could be kept stationary.

No definite indication of reflection was obtained. A General Electric oscillograph, preceded by a power amplifier, was substituted for the cathode ray tube so that photographic records could be made. Some effects were obtained, but they were not very consistent.* The wave form of the transmitted pulses was checked and found to vary with the operation of the chopper. Breit and Tuve did not regard these tests as conclusive.

Breit and Tuve next tested in July, 1925, at night, from KDKA at Pittsburgh, Pennsylvania. In these tests the transmitter was modulated by means of a 60-cycle plate voltage supply. The wave-length was 309 meters. Because of pronounced fading, the experimenters were inclined to disregard the small consistent hump which appeared in one instance; even the main hump was considered as a reflection.

Successful tests were made on July 28, 1925, at about 10.30 A.M. from the Navy's crystal controlled transmitter. The transmitter—NKF at Bellevue, Anacostia, D. C.—was on 71.3 meters and 41.7 meters: shorter wave tests were not successful. Double humps and at times triple humps were seen. The tests were repeated at 3.15 P.M., when three humps were observed in a rotating mirror and were photographed. A very slight second hump was found in the transmitted wave but its amplitude was not great enough to vitiate the observations. This imperfection was eliminated by proper biasing. In the morning and afternoon of August 6 simultaneous observations were made at Bellevue and at the Department of Terrestrial Magnetism. The first test showed

* It is probable that the first tests could not have succeeded, simply because of an unfortunate choice of wave-length and time. At nine in the morning, 600 meter waves are not ordinarily reflected by the KHL. The tests would probably have succeeded at night; or during the daytime with shorter wave-lengths.

a varying second hump; in the second test a constant second hump was observed. Similar tests were made in the mornings and afternoons of September 21, September 23 and September 25, 1925.

In the several tests the lowest height for the KHL was 55 miles (88.5 kms.); the highest was 132 miles (225 kms.). On the double reflections the layer heights were 55 and 141 miles (88.5 and 227 kms.) and 91 and 125 miles (146 and 201 kms.). The heights were calculated according to the equation $\frac{2h}{c} = \Delta t$, where h = height in miles, c = velocity of waves in miles per second, and Δt = elapsed time. The elapsed time was determined by the ratio of the distance of the peak of the reflected wave from the peak of its parent ground wave to the distance between two ground waves as determined on the oscillograph and by the modulation frequency of 425 cycles per second at the transmitter.

If the reflected waves are downcoming and if the earth is a good conductor, the reflected waves will be re-reflected upwardly with a node of electric intensity at the ground and a loop of electric intensity at a height equal to a quarter wave-length. Three antennas with horizontal portions at 6, 30 and 50 feet above the ground were used to check the interference pattern at 71.3 meters. The antenna at 30 feet showed the strongest signal intensity. If 30 feet is assumed to be the position of the loop of the interference pattern, it can be shown that since one quarter of 71.3 meters is 58 + feet, the angle will be approximately $\cos^{-1} 30/58 = 60°$. Breit and Tuve * considered this *angular indication purely qualitative.*

OBSERVATIONS OF SMITH-ROSE AND BARFIELD.

Smith-Rose and Barfield [22] overcame the difficulties mentioned in their earlier reports by using shorter waves and by employing several different means for measuring the ratio of electric field to magnetic field. Theory indicates that the electric field and the magnetic field will be equal for direct waves, and unequal for the measurable downcoming waves. From the ratio of the two fields the angle of incidence of downcoming waves may be determined.

Many measurements were made at Slough of the strength of signals received from Bournemouth, a distance of 77 miles. These measurements indicated that the angle of incidence was 13° to 34° for the wave-length of 400 meters. The calculated virtual height of the KHL was about 55 miles or 88.5 kilometers. The estimated coefficient of reflection for the layer was 0.2. These observations are in agreement with those of Appleton and Barnett.[1]

* Breit and Tuve also discovered (1) that there were both slow and rapid variations in amplitude of the reflected signal; (2) that the layer is higher in the afternoon than in the morning; and (3) that the layer is higher in the fall than in the summer.

OBSERVATIONS OF HOLLINGWORTH.

Hollingworth [23] made a novel determination of the height of the KHL for long waves, i.e., 14.35 kilometers, in the following manner: A large number of measurements of signal strength were made at different distances along a radial line from the transmitter. These measurements indicated an increase in average signal strength from 300 kilometers until a maximum was observed at about 400 kilometers. The average signal strength then decreased until a minimum was observed at about 650 kilometers. At 650 kilometers the average signal strength again increased with distance up to about 1,000 kilometers.

Hollingworth plotted a graph of signal strength as a function of distance. He next plotted a graph including a family of curves which were based upon the maxima and minima interference fringes of a direct wave and an indirect wave in which the indirect wave was reflected from assumed heights of KHL. In the second graph the assumed heights formed one ordinate; the distances from the transmitter to the receiver formed the other ordinate. By selection, a KHL height was found on the second graph, which showed maxima and minima at distances corresponding to the maxima and minima of the signal strength as plotted in the first graph. The observed conditions were satisfied by a layer height of 75 kilometers as indicated by the height coördinate of the second graph.

FURTHER MEASUREMENTS OF APPLETON AND BARNETT.

Appleton and Barnett,[24] in their preliminary paper, stated that in further experiments "the signal current variations consequent on the wave-length change are to be photographically recorded." This was done by transmission from stations at Bournemouth and at Teddington, on wave-lengths of 386.5 meters and 380 meters, respectively. The transmitted wave was varied at a uniform rate over 10 meters in a 15-second period. At the upper and lower limits, five-second identifying dashes were formed.

The receiver was located at Dogsthrope, Peterborough, which was 236 kilometers from one transmitter and 124 kilometers from the other. The receiver was a four-stage flat amplifier, followed by a two-stage amplifier including sensitivity controlling means. The output was applied through a crystal detector to an Einthoven galvanometer. The signals were recorded on moving bromide film on which 1 centimeter equalled 1 second of film travel. The zero signal line was along the lower edge of the film.

From a number of photographic records, the height of the KHL was determined from 11 P.M. to 5 A.M. The results were plotted. The layer height increased slowly until it reached about 120 kilometers at about sunrise. Thereafter, it fell rapidly at first, and finally levelled off at about 95 kilometers at about 5 A.M.

EXPERIMENTS AND OBSERVATIONS OF HEISING.

Heising's [25] first tests were made in the summer of 1925. In these tests the frequency of the carrier at the transmitter was wobbled and the received signals were recorded on an oscillograph. Since the tests were promising, the apparatus was improved and the following method employed: Dashes of steady high frequency power were transmitted from Deal, New Jersey, for approximately $\frac{1}{16}$ of a second. Spaces of similar duration followed. The frequency of the carrier was varied uniformly during the transmission period. The carrier frequencies were usually 2,700 or 5,260 kilocycles. The frequency variation Δf was between 800 and 4,000 cycles. The receiver was located at Mineola, L. I., a distance of 47 miles from the transmitter. Two paths for the waves were expected. A wave radiated at time t_1, traveling the longer path, arrived at the receiver at the same time that the wave radiated at time t_2 arrived by the direct path. These waves, having left the transmitter at different times, were of different frequencies and therefore produced a beat note. From oscillograms taken on February 17, 1926, at about 4:00 P.M., the layer height was estimated at about 160 miles for a carrier of 5,260 kilocycles. In the evening of the same day, the layer heights were found to be 221 miles and 232 miles at 9:14 P.M. and 9:23 P.M., respectively.

Due to the difficulty of analyzing the complex beats, the wobbler type experiments were stopped in favor of the pulse scheme of Breit and Tuve. In the pulse experiments the pulse duration was usually 0.001 second and the pulse frequency was 60 per second. Oscillograms were made showing the pulses of high frequency current in the transmitter antenna for frequencies of 5,260 kilocycles and 17,800 kilocycles. These signals were recorded on an oscillogram at Albertson, L. I., on February 26, 1926, at 9:19 P.M. and 9:23 P.M. The KHL virtual heights for these observations were 221 miles and 232 miles, respectively, for carrier frequencies of 5,260 kilocycles.

Observations were made at Dickinson, South Dakota, where paths of about 800, 1,300, 1,600 and 2,000 miles longer than the direct path were observed for a carrier wave frequency of 17,800 kilocycles. Many measurements of the virtual heights of the KHL were made. The virtual heights varied from a maximum of about 400 miles to a minimum of about 150 miles. Multiple reflections were observed. In addition to the measurements of the KHL heights, Heising also observed the layer rising at about 6 miles a minute and falling at about 20 miles per minute.

Thus the virtual heights of the several reflecting regions of the ionosphere were first measured by different experimenters employing different methods. The writer is not unmindful of other methods, employing radio waves for the measurement of distance. A few examples of these methods involve the following principles: (1) The capacitance of a pair of conductors mounted on an aircraft varies as an inverse function of the height of the conductors above the earth and therefore the

change in capacitance may be used as a measure of the altitude of the craft.[26] (2) The radiation resistance of an antenna varies as a function of its distance from the earth and hence is an index of height.[27] (3) Observing the falling time of a "radio bomb," which is released from an aircraft whose height is to be determined, has been suggested for the measurement of altitude.[28] Since such other methods are outside the scope of these notes, readers, who wish to know more of that phase of the art, are referred to the technical publications and the patents; we shall now follow the development of the apparatus for timing radio wave propagation and hence for measuring distance.

APPARATUS FOR TIMING RADIO WAVE PROPAGATION.

One of the earliest disclosures of an apparatus for measuring distance by observing the reflection of radio waves is found in Heinrich Löwy's[29] United States Patent 1,585,591 which issued on May 18, 1926, on an application filed on July 17, 1923. The patentee proposes to use the electric counterpart of Fizeau's method[30] for measuring the velocity of light. Instead of using Fizeau's toothed wheel for covering and uncovering a source of light, an electronic switch is used for keying a transmitter on and off and alternately for keying a receiver off and on. Thus the transmitter radiates a short pulse, when the receiver is off; thereafter the receiver is keyed on to respond to the reflected pulse. The receiver output is a maximum, when there is no overlapping of the outgoing and incoming pulses. The receiver output diminishes, if there is any overlapping. Thus an exact timing or frequency of keying, produces signals which indicate altitude. (Breit and Tuve[31] report that Professor W. F. G. Swann and Dr. J. G. Frayne suggested and experimented with a similar method.)

Figure 1 is a combination of Figs. 8, 12 and 14 of the Löwy Patent and the description thereof. The transmitter S includes an oscillator 11. The frequency of the oscillator is determined by the tuned circuit 13, 14′ and 40. The oscillator output is applied to an antenna A and ground 16. The power supply 14 for the oscillator is controlled by an electronic switch 27. Before describing the electronic switch and the modulator M to which the switch is connected, the receiver E will be considered.

The receiver E includes an antenna 51′–52, an electronic detector 48, and indicator I, a meter 53, a compensating network 44, 45, 46, power source 47, and a connection through the electronic switch 27. In the event that there is undesirable pick-up between the transmitter S and the receiver E, a coupling link Z is provided to control or neutralize the undesired pick-up.

The electronic switch 27 consists of a vacuum tube having a cathode 23, cathode ray deflecting elements 24–25, a central anode 37, and two groups of radially arranged anodes 21, 22. The radially arranged anodes are designed so that by connecting one or more anodes the duration of

the cathode ray contact with the anode may be regulated. Furthermore by selecting the anodes to be connected in each group the interval between the contacts may be adjusted. The frequency at which the contacts are made and broken is determined by the rate at which deflecting voltages are applied to the deflecting electrodes 24–25. The deflecting voltages are supplied by a modulator M.

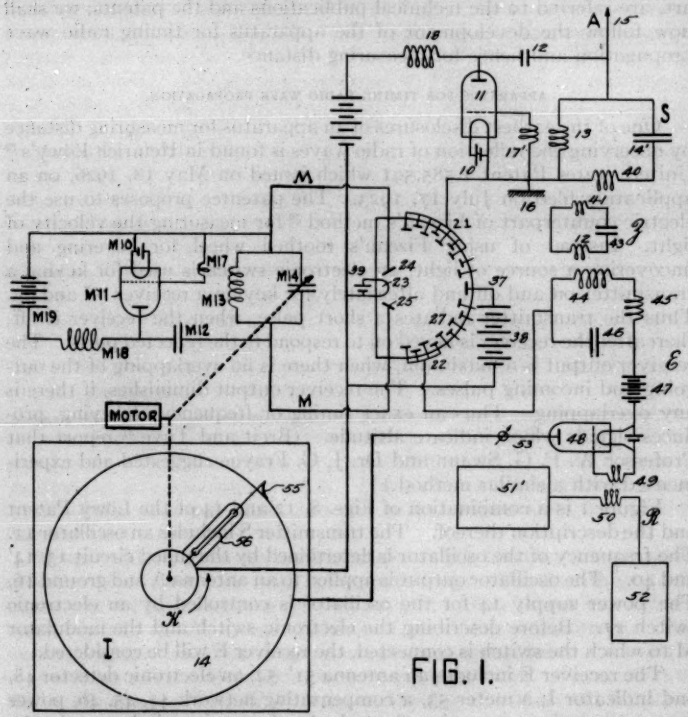

FIG. 1.

The modulator includes a tuned circuit M13, M14 which is suitably connected to a vacuum tube oscillator M11. The modulator frequency is controlled by a variable capacitor M14. The capacitor may be adjusted manually to a particular value or may be varied continuously. For continuous adjustment the capacitor is connected to a motor. The motor is also connected to the indicator I so that the modulator capacitor and the indicator tube are rotated synchronously. The indicator in-

cludes a gaseous discharge tube 56 which is connected through a suitable slipring and brush 55 to the receiver output circuit.

The operation is as follows: When the modulator M applies a positive potential to the deflecting electrode 24, the cathode ray will be deflected from the central electrode 37 to the upper group of the radially disposed anodes 21. The cathode beam will then complete the power circuit of the tube 11. Oscillations will be generated and radiated from the antenna. During this period the receiver will be inoperative because the anode circuit of the detector 48 will be open. The application of a positive potential to the deflecting electrode 25 will deflect the cathode ray to the lower group of the radially arranged anodes 22, and hence the anode circuit of the detector 48 will be made operative through the electronic switch 27. If a reflected signal is received, the gaseous discharge tube 56 will flash and will indicate the altitude on the indicator scale which is not shown. Since the transmitter keying rate is continuously varied, the minimum to the maximum distance range of the device will be covered and reflections from objects at different distances will be indicated.

Löwy points out that the time required for a pulse of radio frequency energy to travel to the reflecting object and back to the receiver is $t_2 = 2H/c$, where t_2 = elapsed time, H = distance from device to object, and c = velocity of propagation of radio waves. The maximum modulation wave-length l should be not less than four times the longest distance to be measured. He also states that for any particular distance h', the instantaneous modulation wave-length l' will equal $4h'$ because for that condition the received reflected signal will be a maximum. The foregoing represents only one of the several arrangements described in the patent.

TRANSMITTER MODULATING DEVICE.

In an article published in 1928, Tuve and Dahl [32] describe an improved device suggested by Dr. G. Breit for modulating a transmitter employed in KHL pulse echo measurements. The previous work of Breit and Tuve [2] utilized a transmitter which was modulated by superimposing an alternating e.m.f. of 500 to 1,500 cycles to vary a high negative bias applied to the intermediate amplifier of the transmitter. With this arrangement power was radiated during a portion of the positive half cycle of the applied e.m.f. The "off" period was only slightly longer than the "on" period. This led to poor resolution for small distances, incomplete resolution for certain types of multiple reflections, and ambiguity between "reflected peaks" and "ground peaks." While these objections might have been overcome by higher voltages and higher frequencies, excessive modulation voltages would have been required and higher frequencies would have shortened both the pulses and the intervals between them.

The modulator was improved by an arrangement utilizing in an unbalanced condition the "multivibrator" circuit of Abraham and Block.[33] The multivibrator consisted of a pair of 201 A tubes connected with anode resistors of .05 megohms, grid resistors of 0.1 and 1 megohms, coupling capacitors of 0.0002 mfd. and 0.001 mfd., and a 90 volt anode supply. The circuit provided approximately 300 pulses per second, each pulse having a duration of about 0.0002 second. These pulses were applied through an audio transformer to the grid circuit of four 50 watt amplifier tubes. The amplifier tubes were connected in parallel and included 100 volts of negative grid bias and grid resistors to prevent overloading. The transformer converted each applied current pulse into a positive voltage peak and a negative voltage peak; each peak was of shorter duration than the applied pulse. The amplified and shortened pulses were again transformed so that the resultant pulses had an amplitude of 1,200 volts and a duration of less than 1/4,000 second.

The pulses from the final transformer were of sufficient power to key two 250 watt tubes which were connected in parallel in the amplifier intermediate the crystal controlled oscillator and the 20 kilowatt tube of the 4,015 kilocycle transmitter at the Naval Research Laboratory at Anacostia, D. C. The oscillograph of the KHL echoes of the transmission using 500 cycle modulation were much less resolved than those using the multivibrator modulation. While some irregularity of spacing was observed, this was not considered objectionable as it helped to identify separate peaks due to direct and indirect waves.

TESTS BETWEEN NEW YORK AND SAN FRANCISCO BY H. O. PETERSON.

Reports of the Radio Corporation of America describe tests made in 1928 by H. O. Peterson.[34] These tests were conducted on the RCA radio circuit which was set up between Bolinas, California, and Riverhead, New York, for facsimile service. The transmitter was keyed by a motor driven commutator, which was capable of establishing well defined dots at frequencies up to 720 dots per second. The transmitted signals were received and applied to a cathode ray oscilloscope. The outstanding signal characteristics appearing on the fluorescent screen of the cathode ray tube were sketched to scale. Some of the cathode ray tube signals were photographed on a moving film.

Ghost or echo phenomena were observed during certain periods of the day. For example, some signals on a wave-length of 33 meters transmitted from 6XB at 2.30 A.M. E.S.T. showed a difference of path length of approximately 780 miles. Signals received from the same station at 2.35 A.M. E.S.T. showed complex echoes. Other tests on 16.8 meters showed that the difference in the path lengths was about 60 miles.

AIRPLANE ALTITUDE INDICATING SYSTEM OF BENTLEY.

The airplane altitude indicating system patented by J. O. Bentley [35] is of the type in which frequency modulated waves are radiated toward

the earth and after reflection are combined with the instantly radiated wave to form beats. The frequency of the beats is a measure of the altitude; i.e., the higher the altitude the higher the beat frequency.

Reference is made to Fig. 2 which corresponds to Figs. 3 and 4 of the Bentley Patent. The transmitter 1 and receiver 2, respectively, are housed in shielded containers indicated by dash lines. The transmitter includes a vacuum tube oscillator 14 whose frequency is varied by a

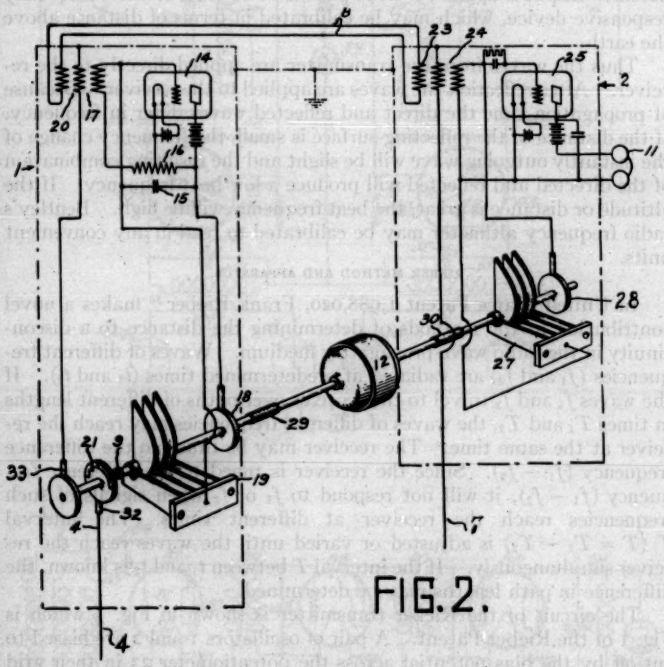

FIG. 2.

motor driven capacitor 19. The high frequency oscillations are applied through a transformer 17–20, a slip ring 33, and a commutator 21 to an antenna 4. The commutator 21 includes an insulated segment so that the high frequency currents are applied to the antenna only as the capacitor 19 changes to produce linear frequency variations in one direction only. Some of the high frequency energy may be applied through a connecting link 8 to the receiver. However, the connecting link may be omitted if the direct pick-up is sufficient. If the direct pick-up is

excessive, loop antennas suitably disposed may be used to minimize the coupling between transmitter and receiver.

The receiver consists of a detector 25 which is connected through a transformer 23–24 to an antenna 7. The receiver circuits may be tuned by a variable capacitor 27 that is mechanically connected to the motor 12 so that the transmitter and receiver are tuned synchronously. The capacitor 27 is connected through a slip ring 28 to the detector. The detector output is applied to head phones 11 or other suitable frequency responsive device, which may be calibrated in terms of distance above the earth.

Thus the waves from the transmitter are applied directly to the receiver. After reflection the waves are applied to the receiver. Because of propagation time the direct and reflected waves differ in frequency. If the distance of the reflecting surface is small, the frequency change of the instantly outgoing wave will be slight and the resulting combination of the directed and reflected will produce a low beat frequency. If the altitude or distance is great, the beat frequency will be high. Bentley's radio frequency altimeter may be calibrated to read in any convenient units.

RIEBER METHOD AND APPARATUS.

In United States Patent 1,988,020, Frank Rieber [36] makes a novel contribution to the methods of determining the distance to a discontinuity in the radio wave propagating medium. Waves of different frequencies (f_1 and f_2) are radiated at predetermined times (t_1 and t_2). If the waves f_1 and f_2 travel to the receiver over paths of different lengths in times T_1 and T_2, the waves of different frequencies may reach the receiver at the same time. The receiver may be tuned to the difference frequency $(f_1 - f_2)$. Since the receiver is tuned to the difference frequency $(f_1 - f_2)$, it will not respond to f_1 or f_2 when signals of such frequencies reach the receiver at different times. The interval T $(T = T_1 - T_2)$ is adjusted or varied until the waves reach the receiver simultaneously. If the interval T between t_1 and t_2 is known, the difference in path lengths may be determined.

The circuit of the Rieber transmitter is shown in Fig. 3 which is Fig. 1 of the Rieber Patent. A pair of oscillators 1 and 2 are biased to cut-off by the bias potential across the potentiometer 23 in their grid circuits. The grid circuits are connected in push-pull to a low frequency generator 21. The low frequency generator applies potentials to first one, then the other, of the grid circuits so that the oscillators are alternately keyed on. The oscillators, which are tuned to different frequencies f_1 and f_2, are connected through power amplifiers 43, 43 to the antennas 54 and counterpoises 56. The interval T between the operation of the oscillators is varied by adjusting the potentiometer 23 or by changing the frequency of the generator 21. The potentiometer is preferably calibrated in suitable units of length.

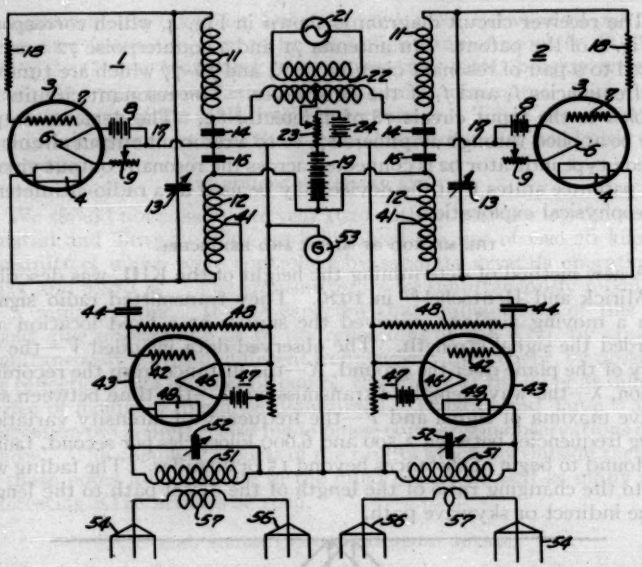
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FIG. 3.

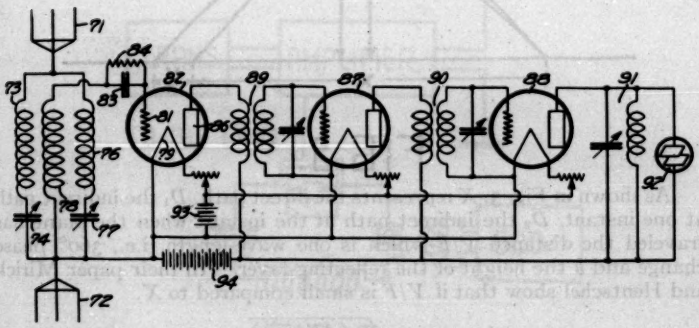
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FIG. 4.

The receiver circuit diagram is shown in Fig. 4, which corresponds to Fig. 2 of the patent. An antenna 71 and a counterpoise 72 are connected to a pair of resonant circuits 73–74 and 76–77 which are tuned to the frequencies f_1 and f_2 of the two waves. The resonant circuits are coupled to the input circuit 78 of a detector 82. The detector output may be applied through amplifiers 87, 88 to a resonant output circuit 91. A neon type indicator 92 is connected across the resonant output circuit. The patentee states that the device may be used as a radio-altimeter or in geophysical exploration.

THE METHOD OF MIRICK AND HENTSCHEL.

A new method of determining the height of the KHL was described by Mirick and Hentschel [37] in 1929. They transmitted radio signals from a moving airplane, received the signals at a fixed location and recorded the signal strength. The observed data included V—the velocity of the plane over the ground, X—the distance from the recording station, λ—the wave-length of transmission, T—the time between successive maxima of signal and F—the frequency of intensity variation. Using frequencies between 2,500 and 6,000 kilocycles per second, fading was found to begin at distances beyond 15 or 20 miles. The fading was due to the changing ratio of the length of the direct path to the length of the indirect or skywave path.

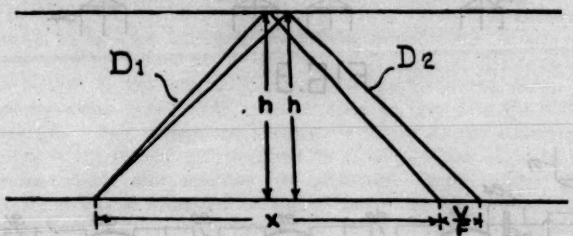

FIG. 5.

As shown in Fig. 5, X represents the direct path, D_1 the indirect path at one instant, D_2 the indirect path at the instant when the plane has traveled the distance V/F which is one wave-length, i.e., 360° phase change and h the height of the reflecting layer. In their paper Mirick and Hentschel show that if V/F is small compared to X,

$$h = \frac{X\sqrt{\lambda\left(\frac{2V}{F} - \lambda\right)}}{2\left(\frac{V}{F} - \lambda\right)}.$$

In measurements taken on December 20, 1928, between 11 A.M. and 1 P.M. at a frequency of 2725 kc. on a flight from Anacostia, D. C., to Havre de Grace, Maryland, and return, the KHL heights were determined as 73.4 miles maximum to 53.4 miles minimum. Many other determinations of the KHL heights were made. These determinations were in fair agreement with the measurements made by previously cited observers.

KHL STUDIES BY HAFSTAD AND TUVE.

We should not pass by the year 1929 without mentioning the work of Hafstad and Tuve.[38] This work involved the use of two 20 kilowatt transmitters which were controlled by separate crystals operating on 4,435 and 8,870 kc. The transmitters were simultaneously modulated by a multivibrator. It was expected that transmission of this type would give information as to the reflections of the KHL by applying simultaneously waves of different frequencies. Moreover, by observing the reflections at a number of points, the effects of the layer at different angles of incidence might be determined. Hafstad and Tuve [39] at the suggestion of G. Breit [40] also made phase comparison observations of the echoes. The complete reports of the results which are outside the scope of these notes are available in the cited papers as well as many other interesting KHL articles of 1929.

ECHO SYSTEM PROPOSED BY GEORG GOUBAU.

Georg Goubau [41] working under the direction of Prof. Zenneck measured KHL echoes occurring north of the Alps. The transmitter circuit,

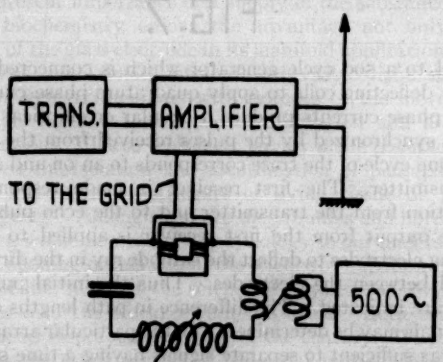

FIG. 6.

shown in Fig. 6, consists of a transmitter and a neutralized high frequency amplifier. The grid circuit of the amplifier is biased to prevent

transmission except during predetermined pulse periods. These periods are determined by a 500 cycle generator which is connected to an iron core choke. The choke differentiates the applied 500 cycle currents so that sharply defined positive and negative voltage pulses are obtained. The positive pulses key on the amplifier which then applies pulses of radio frequency power to the antenna.

The receiver circuit is shown in Fig. 7. The first receiver is connected to the deflecting plates of a cathode ray tube; the second receiver

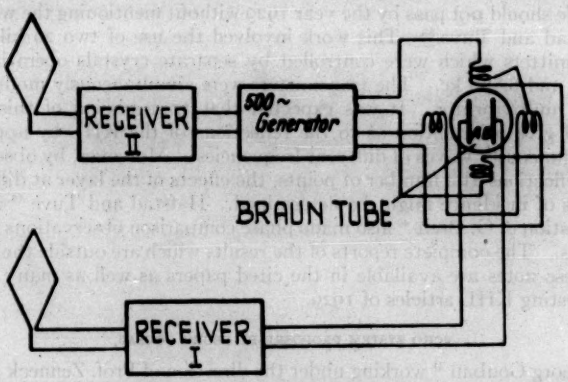

FIG. 7.

is connected to a 500 cycle generator which is connected to pairs of cathode ray deflecting coils to apply quadrature phase currents. The quadrature phase currents produce a circular or elliptical trace. The generator is synchronized by the pulses received from the transmitter. Therefore, one cycle of the trace corresponds to an on and an off period of the transmitter. The first receiver is made responsive to the direct radiation from the transmitter and to the echo pulses from the KHL. The output from the first receiver is applied to the cathode ray deflecting electrodes to deflect the cathode ray in the direction of the electric field between the electrodes. Thus the initial pulses and the echo pulses are indicated. The difference in path lengths of the direct and echo signals may be determined. In the particular arrangement the resolution was sufficient to separate signals having a time separation of 1/10,000 of a second. According to later experiments, a single receiver was used to synchronize the cathode ray sweep and to detect the signals.

(To be continued.)

THE APPLIED SCIENCE OF NUTRITION.

BY

ROBERT R. WILLIAMS.

Revolutionary advances in biochemistry have occurred during the past three decades. One has only to recall the appearance of the rudimentary, merely clinical laboratory associated with the medical school of thirty years ago in contrast with the well equipped biochemical laboratory of today to appreciate the changes that have come about. Then, elementary analysis of organic compounds was not attempted in workaday laboratories. It was performed with a ponderous gas furnace and with a relatively crude analytical balance so that a sample of about 200 milligrams was regarded as the normal requirement of substance for a single elementary determination. This fact alone meant that the determination of the structure of a moderately complex compound from nature required first the isolation in pure form of a half pound or so of the substance.

Microanalysis has changed that by a factor of 100 to 1,000 so that with fair luck and discernment a single gram may suffice. The possession today of such a quantity, of pure penicillin, for example, would probably clear the road for its abundant synthetic production within a matter of months since the best talent could be promptly enlisted in view of the present importance of a supply of the substance.

Modern biochemistry enjoys the advantage not only of microanalysis, but of the glass electrode in its manifold applications to electrometric analysis, ultraviolet, infrared and visible light spectroscopy, tagging of molecular fragments with isotopes of the more significant elements, high vacuum techniques of distillation and a score more modern inventions. These tools have largely made possible in the past decade or two the isolation and identification of perhaps a hundred minute but important constituents of living tissue or products of metabolic process. Among them are the vitamins and hormones which have opened a whole new realm of physiology to our understanding.

With the opening of this realm, the science of nutrition has taken on a new lease of life, much as the science of physics was revivified by its first glimpses into the world within the atom. Both sciences came nearly to a dead stop about the turn of the century. Physics thought it had solved the fundamentals of molecular motion, heat, light, and electricity, and was even content to gloss over the shortcomings of its insight into magnetism. Then came radioactivity yielding to Rutherford, Bohr and many others the concepts of atomic structure, nuclei and electrons, orbits or levels, Planck's quantum of energy and so forth,

not only opening up a new field for physics but reilluminating her already familiar fields.

Nutrition likewise had gotten into a rut. Thinking had been paralyzed by an attractive picture likening the animal body to a furnace fed by fuel, furnished with an ash pit where the solid residues of the fuel collected and ventilated by a flue through which passed the gases of combustion. The more ventilation, the more fuel could be consumed and the greater was the heat output. The analogy was so good that physiologists were lulled into a complacence that forbade them to wonder why the combustion took place at so uniform and so low a temperature and could even be permanently interrupted by raising the body temperature very slightly.

The newer knowledge of nutrition, as it has been so aptly called, was only in part (and in fact in later part) due to advances in biochemistry. It was even more due to belated resort to long term feeding experiments, a procedure that had been available all the time but neglected. In the era of calorimetric idolatry, short feeding experiments had of course been used. The disposal of a single meal was a favorite subject of study. This approach, however, neglected any influence that prior feeding may have had on the animal's capacity to utilize the experimental meal. It took the body furnace for granted and ignored the fact that it is in dynamic equilibrium with its surroundings and is constantly undergoing a nutritional process of self-repair. Accordingly, the mere lengthening of the term of observation in feeding experiments from hours to weeks or months, as introduced by Eijkmann, Hopkins and Mendel, had revolutionary consequences.

The most amazing result in a philosophical sense of the modern study of nutrition and the discovery of the essential role of vitamins (as the precursors of catalytic agents or enzymes for the most part) has been the revelation of the close physiological and chemical kinship of all living tissues. The yeast cell utilizes sugar in a series of steps marking a pathway which human metabolism also follows. The vitamins perform the same functions in plants that they do in man. While we derive our supplies of vitamins from the plants, they make the vitamins largely for themselves. We feed upon the bodies of our forebears from whom we inherited the "know how" to metabolize food.

From the standpoint of human health, our recently acquired knowledge of nutrition must be ranked next in importance to the demonstration by Pasteur in the previous generation of the bacterial origin of infectious and contagious disease. The application of nutritional knowledge to public health, however, presents many contrasts to that of the application of pathogenic bacteriology. Many of the first and most striking successes of applied bacteriology came in the field of surgery and were carried out by professional hands. Further successes in the field of medicine only awaited an acquaintance with the

principles of bacteriology on the part of physicians. Even today the sanitary and preventive applications of bacteriology are largely in the hands of professional engineers and sanitarians who are concerned with water supply, sewage disposal and to a limited extent with control of insects as infective agents. There has been little need for reliance on the intelligent lay use of the principles of bacteriology, though especially in the field of tuberculosis lay coöperation has been a major aid.

By contrast, it would appear that the practical application of nutritional knowledge must largely become and remain a household affair. Our contacts with infective agents are occasional and incidental while food is part of the unvarying routine of the daily life of every human being. Application of knowledge about food cannot therefore be relegated to professional hands but must become the duty of every layman. It is not a matter primarily for the hospital or the physician's examining room but for the kitchen. In accordance with the principle that everybody's business is nobody's business, the adaptation of modern knowledge about foods to practical human nutrition has lagged. The vendors of poultry and cattle feeds forged well ahead of the vendors of human food in the use of scientific knowledge because chickens and cows are fed with an eye to measurable results, while humans eat to gratify their tastes.

Evidence of need for improved nutrition even in relatively well fed America is of two sorts. First, surveys of the dietaries of American families, chiefly urban, show a marked relationship between income and adequacy as judged by what is known of the needs of experimental animals. The most extensive survey, by Stiebeling and Phipard, is typical and shows that the diets of low income people generally would not induce optimum biological performance in rats, for example. Second, clinical evidence among hospital populations shows the extensive occurrence of dietary deficiency symptoms, usually in mild form but often in severe form in city slums and poor rural areas. Many examples can be found of rehabilitation by improved nutrition. Unfortunately time does not permit a fuller discussion of this fundamental topic.

This need afforded an opportunity for a useful campaign of public promotion of nutrition and led to the organization late in 1940 of the Food and Nutrition Board of the National Research Council, as well as a Nutrition Division in the Office of Defense Health and Welfare Services under the Federal Security Agency. The function of the former was to codify useful knowledge as a basis for food policy and to formulate and propose practical measures. The Nutrition Division of Defense Health and Welfare Services was conceived as an agency to carry the gospel to homes and institutions through local public health authorities, schools, women's organizations, local nutrition committees, Red Cross groups and the like. The two units thus supplemented one

another, sharing the task of practical reform in mass nutrition where needed.

The Food and Nutrition Board selected as its first chairman, Dr. Russell M. Wilder of Mayo Clinic, who brought to the work an extended medical experience in the field of metabolic disorders, familiarity with the work of the Food Council of the American Medical Association and a prestige among practicing physicians. A year later he was succeeded by Dr. Frank G. Boudreau who had previously had twelve years of service with the Health Organization of the League of Nations in Geneva.

Particular point was given to the timing of the National Nutrition Program by the enactment of the Lend Lease Act in 1940 which clearly foreshadowed to discerning minds the later entry of the United States into the war. The keynote of the program was accordingly one of summons to the populace to military preparedness on the home front. A National Nutrition Conference in May 1941 was much advertised in the press and on the radio and the movement was thus provided with a send off. The resulting ballyhoo undoubtedly created an unfavorable impression on many sober students of nutrition long accustomed to the quieter ways of scientific circles. However, the more practical minded recognized the necessity for slogans and a lively presentation if the public were to be measurably affected by the undertaking. No doubt there was some overstatement of the extent and severity of malnutrition, especially by those sympathetic with the doctrine of "the forgotten man," but on the whole it was necessary to focus public attention on the really great nutritional needs of low income groups in America. Sound and conservative nutritionists will also support the view that there is a widespread sporadic incidence of nutritional deficiency among higher income people formerly considered well fed.

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One of the earliest tasks of the Food and Nutrition Board which is now composed of some forty specialists was to formulate a statement of the daily needs of human beings for the principal recognized nutrients which must be looked for in an adequate dietary. A special committee headed by Dr. Lydia J. Roberts submitted and resubmitted its proposals. The final statement as adopted by the Board after months of discussion took the form of "Recommended Dietary Allowances." It set forth desirable levels of daily intake of total calories, proteins, vitamins A and D, thiamine, riboflavin, nicotinic acid, ascorbic acid, iodine, calcium and iron. No attempt was made to fix proper levels for the lesser known vitamins partly because insufficient knowledge is available and partly because the prevalence of deficiencies of them appears slight. Of the mineral elements, only those were mentioned which are considered likely to be significantly lacking in the dietaries of substantial segments of the population.

The "Recommended Dietary Allowances" thus constitute a standard

chosen for practical rather than theoretical reasons. Proper nutrition undoubtedly requires small amounts of many substances not enumerated among the allowances, but it was felt necessary and wise to concentrate attention on those items which experience had shown were most liable to be at fault. These allowances differ from the dietary standards set by the League of Nations Health Organization in 1935 in that the former fix desirable levels while the latter aimed at a statement of minimal needs. The allowances are accordingly higher. Actually the relative liberality of the allowances also reflects an increasing awareness of nutritionists that there is a large gap between the levels of nutrients required for survival in nominal health and those required for insurance against loss of efficiency and against sense of malaise. A large part of the nutritional shortcomings of the better fed portion of humanity lies in this twilight zone. It shows itself not in forthright deficiency disease but in very mild symptoms which are not readily detected by physicians unless they be specially schooled in rather intricate and difficult methods of diagnosis. Often the deficiencies are clearly discerned to be present only by favorable response to proper therapy. The patient is often unconscious of a need till he experiences a physiological lift upon its fulfillment. Unfortunately subjective psychological effects are often not distinguishable from those due to physical factors and so there remains room for debate. Only statistical observations among large numbers of people have sufficed to establish the validity of the general conclusion.

These "Recommended Dietary Allowances" have already found many uses. They constitute norms fixed by a body of distinguished American students of nutrition available to the rest of the world for discussion and study. They furnish a guide for consideration and help to focus the aims of further experiment in the light of which further revision of the standards is to be anticipated.

They also supply a basis for the instruction of the masses. However, for this purpose, it has been deemed wise to depart from the parlance of science and to use that of the average home. Amateur calculations of dietary adequacy have often resulted in bizarre conclusions. More often than not a quaint emphasis has been placed upon some triviality and the main point of sound dietary choice has been missed. This is not strange for nutritional science has become a complicated matter and no simple formula for arithmetic calculation is possible. Rather than encourage a mere babble about vitamins, minerals, calories and so forth, it was generally agreed that all pretensions to precision should be abandoned in favor of essentially truthful rules, simple enough to be readily remembered. For such purposes, the allowances have been translated into a classification of foods into seven basic types, each of which should be represented in the dietary daily when possible. These seven basic food types are as follows:

1. Green and Yellow Vegetables (Raw, Cooked, Frozen or Canned).
2. Oranges, Tomatoes, Grapefruit, or Raw Cabbage or Salad Greens.
3. Potatoes and Other Vegetables and Fruits.
4. Milk and Milk Products; Cheese.
5. Meat, Poultry, Fish, or Eggs, or Dried Beans, Peas, Nuts, or Peanut Butter.
6. Bread, Flour, and Cereal (Natural Whole-Grain—or Enriched or Restored).
7. Butter and Fortified Margarine.

If a customary serving of one or more representatives of each is included regularly in the diet, there is reasonable assurance that the recommended dietary allowances will be approximated.

Another use of the recommended allowances is to furnish a basis for judging the adequacy of the dietaries of institutions. Under wartime conditions of crowding, of overtime work and of restricted gasoline for travel, the feeding of industrial workers at war plants has often proven inadequate. This was shown by a survey conducted by a committee of the Board under Dr. Robert S. Goodhart of thirty war plants scattered over the country. The shortcomings are naturally greatest in plants which have expanded very rapidly till the capacity of feeding facilities have been overtaxed. This report and the advisory work associated with it has been influential in bringing about some measure of reform both by interesting corporate management in the needs of workers and by guiding of governmental policy in rationing food to industrial plants. The Committee on Nutrition of Industrial Workers is extending its work to gain further knowledge of the influence of diet on health, absenteeism and accidents. There is warrant for believing that the effects upon the output of factories are calculable.

Another use which has been made of the recommended allowances is that of a yardstick for the adequacy of army rations. The office of the Quartermaster General has extensively examined its purchases and its practices in the light of these standards. It has called for extensive additional data on the composition of foods. Steps have accordingly been inaugurated by a committee under the chairmanship of Dr. C. A. Elvehjem to collect such figures from all available sources. An important resource for this purpose is the files of the laboratories of the food industries where a vast amount of unpublished data reposes. Government laboratories and experiment stations have also accumulated many figures which will help to furnish an ultimately comprehensive dictionary of food composition.

An important aspect of food composition which has been revealed by studies already undertaken is the composition of foods as eaten as distinguished from that of the foods in the raw state. Astoundingly large losses of nutrients in cooking have been encountered. This is

especially true in restaurants and institutions where large quantities of food are prepared and held for hours before they are consumed. The steam table is a conspicuous offender. This revelation makes it appear probable that the nearly universal and rarely questioned custom of cooking most foods may be a major factor in the nutritional disorders of the entire human race. Such a view will require confirmation, of course.

The work of the Food and Nutrition Board has naturally stimulated research on many points. One of the outstanding problems associated with nutrition is that of the prevalence of dental caries. The belief is widely held that this is primarily, if not purely, due to dietary causes. However, while tooth growth or tooth soundness have been experimentally demonstrated to be affected by each of several nutritional factors, such as intake of vitamins C and D and of calcium and fluorine, it is not possible to integrate the results as significant and practical conclusions. A reëxamination of the entire subject is now under way under the auspices of the Board in the hope that some plausible hypothesis can be reached as a basis for further experimental study. A really competent thesis regarding the etiology of dental caries would be an obvious boon to humanity. The remedy may be vastly simpler than one could have guessed a decade ago.

The foregoing activities of the Board represent efforts to promote nutrition by research and public education. There is another approach to better nutrition which has had a large place in the Board's program and indeed was the focal point for the organization of the Board. This is the explicit correction of over-refined staples centering about the so-called enrichment of white flour and bread.

This has been the subject of no little debate both in the Board and elsewhere for two principal reasons. The first relates to the merit of retention in the flour of the vitamins and minerals of wheat versus that of addition of synthetics. The second concerns the adaptation of the enrichment program to the requirements of the Federal Food, Drug and Cosmetic Act and latterly to necessities of war rationing of foods.

It has been argued by the adherents of retention of the vitamins of natural origin that it is unsound to permit devitalization of our cereals by over-milling and subsequently to repair the damage as far as possible by addition of products of chemical factories. Their formal logic is irrefutable on its face. However, the practical difficulties of putting it into effect have proved very great. An early and general success by that route is clearly impossible in North America. The restorative approach on the other hand has achieved an astounding degree of success in a relatively short time.

There have been many efforts to promote the consumption of whole wheat flour and bread in all countries of the West. Many of these efforts have been commercially motivated and often they have been

local in scope. The most extensive effort in this direction in recent times was the launching of the so-called "Staff" bread in the United States. This well made product was marketed with the aid of an extensive advertising program by one of the largest baking concerns in this country. The campaign was inaugurated almost simultaneously with the promotion of enrichment of flour and bread and therefore enjoyed the impetus of a tremendous popular nutrition program with government support. Yet the improvement of bread by the natural route failed to gain in popularity while the artificial process was increasingly successful.

The explanation, superficially at least, is that the public taste in staple foods cannot be quickly altered. Perhaps there is some fundamental nutritional reason for public distaste for whole grain staple cereals, but if so it remains obscure. It is true that in some countries, for example Russia, dark bread has remained the staple of the masses, but wherever the milling of grain to whiteness has once become established, reversal of habit is very difficult.

An important illustration of this fact is the attempt upon the part of the Swiss Government in 1937–38 to encourage the use of a darker flour comprising 83 to 85 per cent. of the wheat grain. By putting a tax upon the offals from wheat, a price adjustment was secured so that the new bread, known as "pain integral," sold about 25 per cent. cheaper than white bread. Under the stimulus of government educational promotion, the dark bread had an early success and constituted about 75 per cent. of the total consumption during the first month. However, sales dwindled steadily in the succeeding weeks and months till they had shrunk to 8 per cent. of the total consumption two years later.

The use of rice in the Orient shows a similar history. Whiteness of rice remains for the mass of Orientals a badge of quality, just as whiteness of bread is popular in the West. As early as 1911, beriberi was well nigh eradicated from the Philippine Scouts by the simple expedient of issuing undermilled rather than white rice in their ration. This body of troops which later distinguished themselves for valor on Bataan and Corregidor was already at that time a source of pride to the Filipino people. One might have thought that the civil population could readily be persuaded to follow their example in the choice of rice. However, all attempts to legislate white rice out of existence as a staple by placing a heavy tax on it have uniformly failed in spite of the fact that beriberi long constituted one of the principal causes of death in the Philippine cities.

Active controversy is still in progress on the relative merits of the artificial versus the natural mode of improvement of our basic cereal. Britain has chosen to achieve the result by outlawing during the war the production of white flour and bread. The National wheat meal loaf is composed of flour representing 85 per cent. extraction of the grain.

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Under the conditions prevailing in England, the product has been accepted with good grace by the public in spite of opposition by millers and bakers. Under wartime conditions, 85 per cent. extraction of wheat represents a major economy of shipping space since a fifth more human food is obtained from a bushel of wheat. It is also of advantage for purposes of storage of reserve stocks to ship wheat to England as grain rather than as flour which does not keep as well. There are therefore patriotic motives behind the policy. Whether it will endure after the war remains to be seen.

A similar policy has been adopted in Canada on the advice of Canadian nutritionists. However, the retention of nutritional values by modification of the milling process has been slight. Even so, the modification has not proved popular and improvement of the cereal supply has made little headway in Canada.

In the United States, enrichment has had a notable success due to the joint support of government and the baking and milling industries. At the outset of the program in May 1941, about 30 per cent. of the bakers' bread and approximately an equal proportion of the family flour began to be enriched. These were largely products of the larger bakeries and flour mills although some local bakeries participated. There was a relatively small amount of positive opposition in the industries though some opposition was vigorous and outspoken. Among nutritionists, there was also some opposition, based principally on the idea that artificiality in foods should not be encouraged.

For the most part, however, the lag in further extension of the practice was due to neglect both on the part of industry and on the part of teachers of nutrition. Industry, recognizing that there was as yet little public demand for enriched products, hesitated to pay the costs amounting in that period to 40 cents per barrel of flour, approaching 10 per cent. of the selling price of the cheaper grades of flour. Especially millers serving low income trade found it difficult or impossible to meet the price competition of unenriched products. This has continued to be a shortcoming of the program, especially in the South where home-made biscuit remains the most popular form of bread.

Neglect on the part of local leaders of nutrition groups to promote enrichment was partly due to the impression that the industries were profiting by the program and that they could well afford to pay the costs of promotion. In some localities enrichment was even opposed by nutrition groups on the ground that it was a profit motivated racket. This was, of course, an essentially false idea as the only possible immediate profit to individual bakers or millers was in taking business away from their non-participating competitors in areas where there was public recognition of the nutritional merit of the enriched products.

Due to these causes, the program halted throughout 1941. Many of the original participants were discouraged by lack of public demand

and dropped the practice, while others in localities where promotion was more effective took it up sufficiently to offset the desertions. At the end of 1941 the program was in danger of abandonment and only a vigorous effort to enlist popular support kept it going. As the local leaders of nutrition classes came to understand the facts through widespread lecturing and literature promotion on the part of the Nutrition Division of the Defense Health and Welfare Services and the Food and Nutrition Board, enrichment began to increase early in 1942 and reached a level of about 75 per cent. of the bakers' bread and an equal proportion of the family flour of the country. An important influence was the somewhat belated decision of the military authorities to use the enriched products exclusively for troops. The delay was due largely to a feeling that the measure was unnecessary in connection with the relatively ample and varied rations supplied to our armed forces.

Since the middle of 1942, continuation of enrichment has been relatively secure and on a sufficient scale to be of great value. The weakest spots are that the cheaper family flours which find a market among low income groups in the South and the flours used in hotels and restaurants have not been extensively enriched. The former is especially serious as the people affected are among those in greatest need of just such a correction of their refined staples. This has been partly repaired by legislation in 5 Southern States, requiring enrichment of bread and flour.

At the beginning of 1943, the War Food Administration intervened nationally by requiring the enrichment of all bakers' white pan bread. This order of course will have effect only for the duration of the war emergency, but it is serving to extend the practice of enrichment widely among bakers in the meantime. It is to be feared, however, that enforcement, resting as it does largely on appeal for patriotic compliance, cannot achieve approximately complete success. A like order requiring the enrichment of all white flour has long been under consideration but has not yet been promulgated.

It will now be well to touch upon the relationship of this program to the so-called Pure Food Law. This measure originally enacted in 1906 under the agitation led by Harvey W. Wiley has long enjoyed a great popular support. For some decades past, its broad purposes have been so generally accepted by the food industries and so widely adopted by state and municipal authorities that, at least as far as foods are concerned, it may be counted as among the most important and successful reforms of our time.

The original law was enacted before the modern revolution in nutritional knowledge gained headway. The evils in food supply which it aimed at were those of adulteration and misbranding and the measure therefore took the form of an anti-fraud act. It sought to insure that food products sold to the public should be free from pollution with deleterious or worthless ingredients and that the products should be

labelled truthfully so that the consumer would get what he sought to buy. No authority was provided for supervising public dietaries in the sense of making them well rounded in nutritional essentials. No provision was made for requiring the addition of a new ingredient to an established food product. Old-fashioned foods were accepted as wholesome and the law was merely aimed against misrepresentation, expressed or implied.

Although the law was rewritten in 1938 as the Food, Drug and Cosmetic Act and strengthened in many particulars, its fundamental character and purpose remained unchanged. Obviously the act is by no means an ideal instrument for accomplishing the reform now contemplated, yet the two aspects of food supply control overlap sufficiently to necessitate accommodation of the one to the other. The law permits the administrative officer, after public hearings, to fix standards and definitions of foodstuffs when he deems that such action will "promote honesty and fair dealing in the interest of the consumer." It was at hearings under this provision of the act that the earliest proposals were made with regard to fixing a standard for a white flour which would contain, either by retention or addition, the most significant vitamins and minerals of the natural grain.

I shall not burden you with an account of the extensive discussions which ensued regarding the kinds and quantities of nutrients to be specified or the philosophy which should serve as a guide in such matters. There were those who thought the quantities should match those of the whole grain and others who adhered to the view that the kinds and quantities should be determined solely by evidence of prevailing shortages in existing dietaries. There were problems in abundance with regard to methods of analyzing the products for the vitamins, to the technology of their introduction, to losses incurred in baking of bread, to principles of labelling and to the quantities of each nutrient required by humans and the quantities customarily derived from other articles of food.

Suffice it to say that the standard as originally adopted and later revised in the light of newer knowledge requires the presence of 2 milligrams of thiamine, 1.2 milligrams of riboflavin, 16 milligrams of niacin (nicotinic acid) and 13 milligrams of iron per pound of flour. Corresponding quantities are required per pound of bread. These amounts of these ingredients must be present if the products are to be labelled "enriched" when sold in interstate commerce. The word "enriched" was the choice of the Food and Drug Administration, among several suggested, as having true implications regarding the character of the products. Enriched flour is merely a nutritionally enriched variety of plain flour. Plain flour remains a legitimate product and it is a matter of choice for the miller whether he will offer the one or the other or both

to the public. The standards merely fix the qualities which either product must possess if it is to be sold under those names respectively.

The quantities of these nutrients prescribed in enriched flour are reasonably consistent with those present in whole wheat except in the case of riboflavin. In the latter instance, the quantity is more than double that in whole wheat. The higher level in this case arose from a systematic error in the method of analysis of cereals which made the riboflavin content of whole wheat appear that much higher than later experience proves it to be. It is one of the vagaries of compromise that this figure is retained because the widespread prevalence of ariboflavinosis, especially in the South where milk consumption is low, made a high level seem desirable. On the basis of the average amount of flour consumed, the nutrients supplied by enrichment furnish from 17 per cent. to 50 per cent. of the total amounts of each nutrient obtainable from all foods of the average dietary. Enrichment is therefore a major contributor to the total supply of each nutrient.

The philosophy of enrichment of staples may be stated as follows: When the customary diet of a people furnishes inadequate supplies of certain indispensable nutrients, it is well to repair the shortage by encouraging the addition of them to foods which are appropriate vehicles for the distribution of the nutrients to those segments of the population which most need them. There are thus set up channels of trade whereby the diet of the people becomes more complete without conscious choice by the individual. Under ideal operation, an enrichment program would insure that each housewife going to the grocer would be offered an assortment of foodstuffs that would fulfill all the nutritional needs of her family, provided her pattern of choice conformed roughly to prevailing custom. In practice, enrichment can only approach this ideal. It is nevertheless reasonable to suppose that great good will come from this automatic channeling of nutrients to those who may be so ignorant or indifferent as to ignore dietary rules.

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This sort of nutritional reform does not wait on the slow processes of education. It does not run counter to prevailing dietary preferences, such as the preference for white bread. Moreover it is amazingly cheap. Contrary to popular opinion, synthetic vitamins are in most instances much cheaper than those derived from natural sources. Enrichment of the entire bread and flour supply of the nation costs only 25 cents per capita per annum. One can safely defy any one to suggest another modification of the American dietary which promises to make a comparably significant contribution even at twenty times that cost. The fact is that refinement of cereals by milling has for a century prevailingly impoverished the diets of half the population of the globe. Enrichment presents a simple and extremely inexpensive remedy that can and has been put into effect readily and rapidly in the United States. If it

becomes permanent, it will go down in history as the most conspicuous dietary reform which has ever taken place.

By way of perspective, one may turn to another needed dietary reform for comparison. Most nutritionists will agree that an enlarged and uniform distribution of milk in the United States is a first nutritional need. The want of such a milk supply is primarily responsible for the widespread deficiencies of calcium, riboflavin and superior proteins in the diets of low income people. These shortages affect particularly adversely our child population. However, no simple and quick remedy is in sight in this case. A proper increase of milk supply would cost some $13 to $25 per capita per annum. The production of the milk would require radical revision of the agricultural economy of the South. Drought-resisting pastures would have to be developed and very extensively cultivated in replacement of cotton, corn, tobacco and other specialized farming. It will, in spite of all efforts, be the work of a generation to bring it about. One of the most effective steps in this direction is the penny milk program for school children. This in conjunction with the school lunch program is among the most vital and effective of all nutritional reforms now in progress. Unfortunately, it is in the poorest school districts where the need is greatest that it is most difficult to secure appropriation of public funds to supply lunches or milk at less than cost.

We may now turn to the problem of corn. Corn meal and grits constitute staples of the South. They are consumed by many low income people in quantities comparable with those of flour and bread. Indeed corn is the cheapest of all cereals available for human food in the United States. Consequently, it often looms largest in the dietary of the poorest Southern people, especially in hard times. Fortunately, half or more of the corn meal of the South is whole corn meal which has lost no nutritional values by refinement, but it is deficient by nature in niacin. The remainder of the corn products consumed in the South comes from the corn belt and is of the degerminated variety. This is deficient in thiamine and iron as well as niacin.

The disease, pellagra, due to a deficiency of niacin has throughout its history had a significant association with maize. The disease was first discovered among North American Indians in 1600 and the only countries of the globe in which pellagra is regularly prevalent are those which have maize-eating populations. While pellagra can and does occur among people whose staple cereal is white wheat flour, still the fact remains that Italy, Roumania and the United States lead in the incidence of pellagra and the disease is largely confined to the corn-eating areas.

Enrichment of all corn products with niacin is therefore important. To be consistent, degerminated corn products should be enriched with thiamine and iron also. This project is, however, in its infancy. The

large corn millers of the corn belt have, unlike the wheat milling brotherhood, evinced little enthusiasm for enrichment. The thousands of cross roads corn millers of the South who produce the bulk of the whole corn meal are such small and local producers that it will be a major missionary task to reach them. Many of them operate only on Saturdays or rainy days during a portion of the year. Often they are operated by a single common laborer to whom vitamins and nutritional needs are hifalutin nonsense. The work of reaching them one by one is being organized with the aid of the county agents of the Agricultural Extension Service, but some years must elapse before extensive results can be achieved.

In the meantime, corn products enrichment has no status under Federal administrative rules pending the organization of adequate support from the larger millers who ship in interstate commerce.

The enrichment program poses some new problems for the Food and Drug Administration. Obviously, it has already given encouragement indirectly to the already existing urge on the part of food manufacturers to add synthetic vitamins to their products. This movement has been conspicuous in the breakfast cereal field. Most breakfast cereals are now fortified with synthetics, but this has been done on the motion of the manufacturers and without any systematic support of the Food and Nutrition Board or other public agency. The practice is accepted so long as the kinds and quantities of nutrients added are reasonable. Obviously, cereals so treated are better than those which have been deprived of the nutrients by refining. However, ready-to-serve breakfast cereals make a minor contribution to the dietary and are little used by many low income groups. They are not, therefore, suitable vehicles to distribute nutrients to the masses and have not been accorded the privilege of the term "enriched."

Clearly, as food manufacturers progress in such practices, there is danger that many foods may come to take on more or less of a medicated character. This danger is recognized by the Food and Drug Administration, which is disposed to withhold sanction except in cases of indisputable merit. A proposed addition in a given case may be unobjectionable, but the Administration must see to it, if possible, that the competitive addition of nutrients to foodstuffs one by one does not ultimately add up to a preposterous fortification of our food supply with certain nutrients economically available and having a popular appeal to the public.

Recognizing this problem, the Food and Nutrition Board has declared itself in favor of such additions to be fixed by standards only in the following cases, namely, the enrichment of white flour and bread, the fortification of margarine with vitamin A, the fortification of milk with vitamin D and the addition of iodine to table salt. The enrichment of corn meal and grits as products analogous in use to flour and

bread has also been approved in principle. Enrichment of macaroni has been unfavorably considered primarily because of the large losses of vitamins incurred in cooking it in the Italian fashion. Possibly white rice may come up for consideration, if a feasible process of fortification is developed. Beyond these it is the intention of the Food and Nutrition Board to encourage only the use of natural foods, as no comparable benefits are in sight justifying systematic fortification of other foods. The fortification of sugar is specifically opposed on the ground that it may encourage our already enormous sugar consumption at the expense of better chosen components of diets.

Whether the present Food, Drug and Cosmetic Act will permanently serve the purposes of nutritional reform is questionable. Certainly some notable incongruities have developed, such as the classification of enriched bread and flour as "foods for special dietary use," in order to bring them under the more rigorous provisions of section 403j regarding labelling. If after the war it should appear necessary to make the enrichment of bread and flour compulsory in order to make it universal and permanent, occasion may arise to amend the present food law to harmonize it with modern knowledge of nutrition. A few years of further experience will be of service in pointing the way to be taken.

The rising difficulties of food supply during war time has occasioned the organization of the War Food Administration which often turns to the Food and Nutrition Board for advice on questions relating to the science of nutrition. One of the major problems of wartime nutrition lies in the fact that the direct use of vegetable products as human food is vastly more economical of labor and land than is their conversion to animal products by feeding to dairy or beef cattle, sheep, hogs or poultry. Animal products, however, serve not only to satisfy custom but also to satisfy nutritional needs for superior proteins and other factors. The beans, and especially soy beans, constitute one of the best available substitutes for a portion of our foods of animal origin. Germs of grains are another possibility. If worse comes to worst, we may be compelled to reduce greatly our livestock population in order to conserve cereal foods for human use. This constitutes the greatest future problem of wartime food rationing and will require the use of all the knowledge as well as political skill which the food authorities can command.

The War Food Administration is concerned also with problems of supplying certain foods to our allies and to the European populations about to be liberated from the German yoke. Through this avenue, substantial further responsibilities will doubtless flow to the Board as the war progresses and as we pass into the period of European reconstruction. In addition to these official channels, the Board has liaisons with eminent foreign students of nutrition and public health officials in many lands. Through these means, it is hoped that we can render

from our store of American experience useful service in the better nutrition of the world, just as we have profited greatly from British experience in food rationing problems during the war.

One of the vast problems which must ultimately be faced is the eradication of beriberi and other deficiency diseases among the rice-eating millions of the Orient. There, if ever, we shall have need for the most expeditious and economical measures of repair. Perhaps it will be possible to report on this matter to the Franklin Institute five or ten years hence.

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REMARKS OF

MR. WALTER S. GIFFORD

PRESIDENT OF THE
AMERICAN TELEPHONE AND TELEGRAPH COMPANY
ON THE OCCASION OF RECEIVING THE VERMILYE MEDAL OF
THE FRANKLIN INSTITUTE
FRANKLIN HALL, PHILADELPHIA, PENNSYLVANIA
NOVEMBER 9, 1943

PRIVATE ENTERPRISE AND FREEDOM FROM WANT.

I am glad that there is a medal in recognition of industrial management and I am happy and honored to receive the Vermilye Medal with your generous citation. For nearly a century and a quarter The Franklin Institute has closely surveyed the fields of science and technology; and no man could fail to be pleased to learn that his endeavor to afford effective management to a business enterprise which involves the extensive application of those forces finds favor with you.

The art of living may be a higher art than the art of making a living, but the art of making a living is quite fundamental to the happiness of mankind. Industrial management has enabled great numbers of people to combine their talents and vastly increase their effectiveness. It has made possible widespread use of the inventions of mankind. It has played a vital part in the rise of mankind from the certainty of want to the possibility of plenty and this change has come in the last 150 years. This change was generated in the lands where political and industrial freedom were greatest and where man and management had the greatest opportunity.

It has been one of the most sensational improvements in the lot of mankind since the dawn of history.

But it has not produced Utopia, nor a perfect race of human beings, nor has it stopped war, nor has it guaranteed complete employment for everyone at any and all times.

In this very human world our country leads in many ways; in none perhaps more than in the art of management. Yet management was for some years prior to the war not only the "forgotten man" but the much abused man. It was wrongly blamed for much during the depression years. Fortunately the criticisms and attacks were not too destructive. I say fortunately because it has been largely the skill and leadership of American management directing American labor and capital that has made it possible for America to become the Arsenal of the United Nations in this global war.

The achievements of American industry before the war and since have been nothing short of miraculous. Right now, measured by output per worker, we produce half as much again as Canada and twice as much as Great Britain or Germany and three to four times as much as Japan. Precisely how much of that is due to American management and how much to the American worker or to American capital, no one can tell, but clearly the ingenuity and resourcefulness of American management has played an outstanding part in furnishing our armed forces a quality and quantity of equipment that gives them better than an even break with the enemies who were preparing for war years before we started.

When the war began, the United States, with only one-sixteenth of the world's population, had more automobiles than all the rest of the world combined, and as many telephones. We had over one-third of all the radio sets and about one-third of all railroad mileage in the world. We were the leading nation in the world in air transport. We were producing about one-third of all the electric power and also about one-third of all the steel produced in the world. Since the war began we have with extraordinary speed converted our peace-time industries into war industries and increased our output so that our present war production is more than half again as large as that of Germany and Japan combined.

The tonnage of merchant ships completed in September, 1943, was 25 times the tonnage produced in the same month two years ago. Also, more than 2,380 fighting ships and auxiliaries of all kinds have been completed since May, 1940, and in addition 13,000 landing vessels. The Navy Department says, "No naval construction program of comparable size and speed has ever been accomplished by any other nation."

I know of no more typical American story than the history of the airplane. Two brothers who made their living by mending bicycles in a medium-sized town invented it. They lived in a free country where inhibitions were few, where anyone could try anything, where invention and industry were encouraged. Such things happen more often in the free atmosphere of America than elsewhere. Likewise, this atmosphere invigorates industrial management so that when war came the airplane industry here was able to expand so rapidly that we now lead the world with the production of more than 8,000 airplanes a month; probably at least twice the output of the Axis Nations, and as much as that of the other United Nations and Axis Nations combined. And what is more, we can keep up and even increase the quantity of production and at the same time change to new and better types to a degree and with a speed our enemies cannot match. The teamwork of research, design, engineering and production is one of the most notable achievements of American industrial management.

Nearly everyone on the home front has a son, husband, friend or

sweetheart in the armed forces and they, as well as those on the fighting fronts, have a vital interest in this job that American industry is doing. In fact, modern warfare is so much a matter of ships, airplanes, tanks, guns, and electrical and mechanical gadgets that success is bound to come in the long run to those who have the will to win and can produce the most; and the shorter the time needed to produce, the quicker the victory. We Americans can be proud of the record we are making in our war-time production.

But how about the post-war world? One of the freedoms of the Atlantic Charter is Freedom from Want. Clearly there is no country in the world that is as free from want as ours. I refer to what I think the drafters of the Atlantic Charter meant—freedom from hunger and cold. That type of freedom from want, America has already largely achieved; indispensable in this achievement has been the skills of management and management's ability to put to practical use the increased knowledge of science and research. The scientists have pushed back the frontiers of knowledge. They have been encouraged to do that and their results have been put to practical use by management. Moreover, although all scientific discoveries are available ultimately to all the peoples of the world, somehow we in America have made the most use of them. It is because of the genius of the American people and especially, I believe, because of the genius of American industry given free rein in a free country.

There is no question but we have come nearer to securing freedom from want than any other country in the world. We had enough food, clothing and shelter for all even in the depths of the depression. In fact, government programs were put into effect to reduce what was called overproduction of food. Today we are supplying ourselves and our armed forces with food and clothing and at the same time are shipping large amounts to our Allies on Lend-Lease. But a standard of living that consists merely of enough of the necessities of life to go around even in a depression, or enough to spare to send great quantities to our Allies in war-time, is not a satisfactory goal for Americans. Man does not live by bread alone. It is the frustration, the terrible feeling of futility that defeats human beings in our country when mass unemployment makes it necessary for them to live "off the government." In our America, the dignity and worth of the individual is of prime importance.

We Americans strive for not only freedom from want and a high standard of living, but for equal opportunity for all; for opportunity for a job, opportunity for each one of us to develop and enjoy to the utmost our innate abilities—in short, opportunity to make the most of ourselves. And we want for each new generation the opportunity to marry young and bring up their children with even better opportunities than we had. America, the land of private enterprise, still leads the

world in freedom from want, in its high standard of living, and as the land of opportunity. This is not just because of an abundance of natural resources. Other countries have an abundance of natural resources. It is because we have made better use of our natural resources. I am convinced that this is because we have encouraged private enterprise and have striven to keep opportunity open to each and every one of us. In this way we have developed our skilled management that has come more often than not up from the ranks. In the organization with which I have been associated for nearly forty years, management, from foreman and supervisor to president, has been drawn almost entirely from the ranks. In fact all of the top executives started at the bottom. This is true generally of American industry. Worker and management are largely the same people in America—only at different stages of their careers. If ability is there, the way has been open for a man to rise from whatever point he starts.

There are, of course, many millions of persons who make the most out of their lives in ways and careers that are remote from business as such. These people, whether they realize it or not, are dependent upon business for their opportunity to make the most of themselves in the field of their choice; for without the production of at least the necessities of life in abundance for all, only a few—too few—can be free to follow pursuits not directly connected with the production of food, shelter, and clothing.

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It would be ridiculous to be satisfied with the progress we have made toward freedom from want and toward opportunity for everyone—but we can have the satisfaction of knowing that our progress has been greater than that of any other country. There is much to be done to make life after the war more livable for millions of our fellow citizens. It calls for the best thought of all of us and the answer, or rather answers, for I expect there are many, are not easy. It is unbelievable, however, that we shall be so short-sighted that because we had mass unemployment in a period of depression that was world-wide and because we have not yet reached perfection, we should tear down and destroy the very basis of the relatively high standard of living and equality of opportunity which we already possess.

Without freedom of individual enterprise we would, I am sure, lose our high standard of living and cease to be the land of opportunity. We would lose our world leadership and we would greatly weaken our national safety; for we might well no longer be the strong, resourceful nation able to surpass any other nation or combination of nations in the production of the weapons of modern warfare, so vital for defense. Let us not forget that we always have had and will continue to have competition from other countries. Clearly our safety and our well-being depend upon the fullest encouragement to American ingenuity, upon maintenance of our system of freedom of private enterprise. In

fact, I strongly suspect that this freedom is basic and that, without it, in the long run other freedoms cannot exist.

Industrial management is concerned with producing more for all—not merely dividing up what we have. To be successful it requires technical skill, but it requires more than that. It requires the leadership that can only come from faith in the worth of the individual, from confidence in the future of our democracy and its encouragement of private enterprise and confidence in the ultimate solution of problems, no matter how difficult. I believe much of our recent pre-war troubles were due to a widespread defeatist attitude on the part of people generally. I am not referring to those people who were unemployed and had a real cause for despair. It would be difficult to overestimate the damage done by this defeatist attitude and it was so un-American that it was hard for me personally to understand it. We must approach our post-war problems more realistically. To expect widespread unemployment and the end of private enterprise is, in my view, not being realistic. It is more realistic, I believe, to expect plenty of employment and the abandonment of government war-time controls, including taxes that discourage enterprise, as rapidly as practical with resulting further progress in improving our standard of living and in providing equal opportunities for all. Defeatism has no place in America. I know many who are responsible for management of large and small business enterprises. I know none who are not confident of the post-war future. It is with such confidence that management has accomplished so much in the past and will, if not unnecessarily hampered, accomplish so much in the future.

I look forward to good times, to good wages—to a period that will create capital and well-being. That is the usual history of our people. In that creative progress industrial management is one of the important forces. I am proud to be an officer in the army that is producing the wherewithal with which the fighting men will win victory over the Axis—over the planners of National Socialism in Germany and Fascism in Italy and Militarism in Japan—and which likewise will produce the wherewithal with which Americans can continue to win victories over poverty and want as they have since the Constitution set up that liberty which insures economic opportunity. Let us have faith in the democratic way—the way of America.

Most Powerful Motor in the World.—The most powerful electric motor in the world—powerful enough to hoist a destroyer completely out of the water and up to the height of a 15-story building, all in a minute's time—has recently been completed at the Schenectady plant of the General Electric Co. for shipment to the new Geneva, Utah steel mill financed and owned by Defense Plant Corporation, which will be operated by the Geneva Steel Co.

By applying its 7,000 horsepower at the comparatively low shaft speed of 25 revolutions a minute this giant direct-current motor will develop more turning power than any other motor, either alternating or direct current, ever built. It will operate a reversing rougher of a plate mill which will produce steel plates from a slab weighing as much as 20,000 pounds for shipyards and war industry.

The maximum turning power of the motor, which is two and three quarters times the rated 7,000 horsepower, is more than four million pounds-feet. If a rope could be wound around the shaft it could lift a weight of 1,350 tons, which is approximately the weight of one of the four-stack destroyers which the United States traded to Great Britain. The motor could lift this weight at the rate of 200 feet a minute, the approximate height of a 15-story building.

The motor has an over-all length of 44 feet, an outside diameter of 16 feet, and weighs nearly a million pounds; when installed, it will stand 13 feet above floor level. An unusual feature is the absence of the continuous shaft found in most large motors. Instead, the two 3,500 horsepower rotors are built upon hollow cylindrical bodies, coupled together at the center, and provided with flanges at the ends. To these flanges are securely bolted shafts of sufficient size to support the rotor on its bearings and transmit the driving power. This arrangement saves time in erection; also this "hollow shaft" construction being more rigid than a solid shaft, the whole rotor structure is much lighter for the same strength, resulting in an important saving in weight of steel required. Nine freight cars are needed in shipment.

The motor will be powered by a 7,000 kilowatt, six unit flywheel motor-generator set. It will drive a reversing rougher of a 132-inch, semi-continuous plate mill, capable of rolling steel plate in both directions. Slabs six to eight inches thick and 60 inches wide will be fed into the mill and will emerge one-fourth to three-fourths of an inch thick and up to 127 inches wide. One-fourth inch plate would weigh approximately 20,000 pounds and be approximately 200 feet long.

The Geneva steel mill, which will be one of the largest in operation west of the Mississippi River, will supply plate to west coast shipyards and war plants.

R. H. O.

RELATION BETWEEN AREA AND VELOCITY FOR ISOTHERMAL GAS FLOW.

BY

R. C. BINDER.

ABSTRACT.

Relations are given for the isothermal flow of a gas through a tube of varying cross-section. The maximum velocity attainable in a converging tube for isothermal flow is the isothermal acoustic velocity. The critical pressure at the throat is 0.606 times the inlet pressure. Some comparisons between isothermal, adiabatic, and incompressible flow are drawn.

Some important differences between incompressible and compressible flow can be brought out by investigating the relation between area and velocity for a fluid flowing through a tube or nozzle of varying cross-section. Let A represent the cross-sectional area of the tube at any section, v the specific volume of the fluid, and V the average velocity. The equation of continuity states that

$$\frac{VA}{v} = \text{constant.} \tag{1}$$

If the fluid is incompressible, v is constant, and the equation of continuity takes the familiar, special form

$$VA = \text{constant.} \tag{2}$$

Equation (2) is the relation for a hyperbola; there are no critical values in the area-velocity relation for incompressible flow.

There are critical values, however, in the area-velocity relations for compressible flow. Kármán [1] has detailed an analysis for adiabatic flow. The present paper will consider first the problem of isothermal flow, and then draw some comparisons between adiabatic, isothermal, and incompressible flow. It will be assumed that the flow is frictionless and steady, and that the elastic fluid follows the relation $pv = RT$, where p is the absolute pressure, T is the absolute temperature, and R is the gas constant.

ISOTHERMAL FLOW.

The relation between area and velocity can be obtained by combining the equation of continuity, the equation of state, and the energy equation. Differentiation of the equation of continuity gives

$$\frac{dA}{A} + \frac{dV}{V} - \frac{dv}{v} = 0. \tag{3}$$

[1] "Problems of Flow in Compressible Fluids" by T. von Kármán, in the book "Fluid Mechanics and Statistical Methods in Engineering," Univ. of Penn. Press, 1941, page 15.

Differentiation of the equation of state gives

$$pdv + vdp = 0. \tag{4}$$

The differential equation of motion or energy equation takes the form

$$vdp + \frac{VdV}{g} = 0. \tag{5}$$

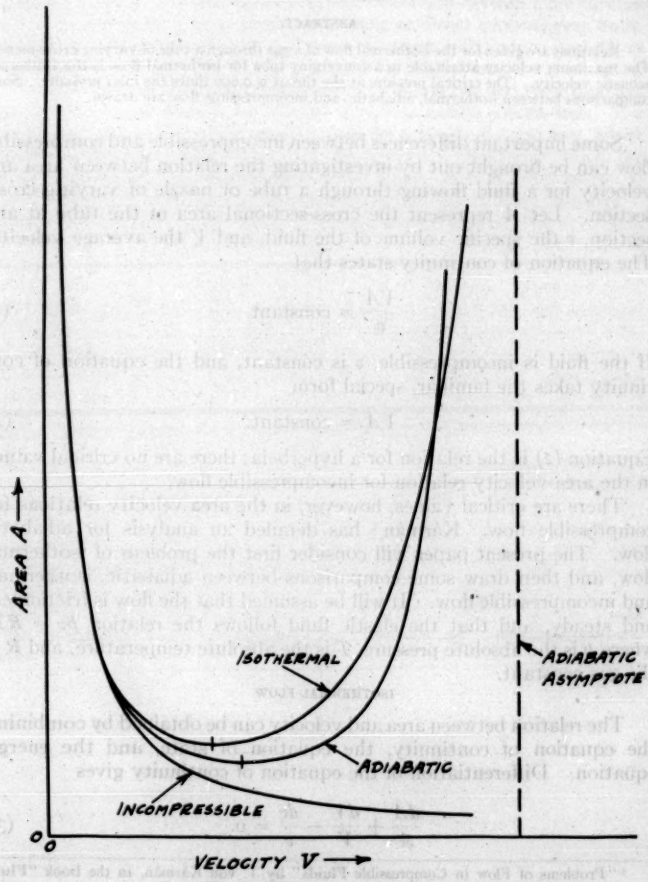

FIG. 1. Area as a function of velocity for different types of flow.

Combining Equations (3), (4), and (5) gives the result

$$\frac{dA}{dV} = -\frac{A}{V}\left[1 - \frac{V^2}{gRT}\right]. \tag{6}$$

T is constant for isothermal flow. The slope dA/dV is positive or negative, depending on whether V^2/gRT is larger or smaller than one. The slope changes from positive to negative at the critical point where

$$V^2 = gRT. \tag{7}$$

When V^2 is less than gRT the velocity increases in a converging channel. When V^2 is greater than gRT the velocity increases in a diverging channel.

For incompressible flow the slope dA/dV is always negative, as can be seen by setting $dv = 0$ in Equation (3).

$$\frac{dA}{dV} = -\frac{A}{V}. \tag{8}$$

A comparison of Equations (6) and (8) shows that the approximation of incompressibility may be fair if V^2/gRT is very small in comparison with one. Integration of Equation (6) gives

$$\log_e A - \frac{V^2}{2gRT} + \log_e V = \text{constant}. \tag{9}$$

If the wave process is isothermal then a pressure wave is transmitted with an acoustic velocity c which is given by the expression

$$c = \sqrt{gRT}. \tag{10}$$

Consider the flow of a gas through a nozzle which first converges, and then diverges. The maximum velocity attainable at the "throat" or section of minimum area is the acoustic velocity c given by Equation (10). Figure 1 shows graphically the variation of area as a function of velocity for incompressible flow and isothermal flow.

There is a question as to the lowest or "critical" pressure attainable at the throat. Figure 2 illustrates the notation. Let p_1 represent the inlet pressure, and p_2 represent the pressure at the throat. The case is taken in which the inlet velocity V_1 is negligible in comparison with the velocity V_2 at the throat. The energy equation and the equation of state give the relation

$$RT\int_1^2 \frac{dp}{p} + \frac{1}{g}\int_1^2 V dV = 0$$

$$\log_e \frac{p_2}{p_1} = -\frac{V_2^2}{2gRT}. \tag{11}$$

Let p_c represent the critical pressure at the throat at which the velocity $V_2 = \sqrt{gRT}$. Then

$$\log_e \frac{p_c}{p_1} = -0.50$$

$$\frac{p_c}{p_1} = 0.606. \tag{12}$$

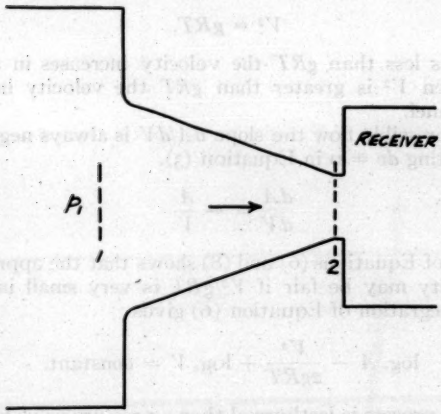

FIG. 2. Notation for flow in a converging tube.

The critical pressure for isothermal flow is 0.606 p_1. For example, if the inlet pressure is 100 pounds per square inch absolute, then the lowest pressure attainable in the converging tube is 60.6 pounds per square inch absolute.

SOME COMPARISONS BETWEEN ISOTHERMAL AND ADIABATIC FLOW.

For a frictionless adiabatic process pv^k = constant, where k is the ratio of the specific heat at constant pressure to the specific heat at constant volume. The acoustic velocity c_a for an adiabatic wave process is given by the relation

$$c_a = \sqrt{kgRT} = \sqrt{kgpv}. \tag{13}$$

Adiabatic flow can be investigated by the same general method of attack employed for isothermal flow. For adiabatic flow there results

$$\frac{dA}{dV} = -\frac{A}{V}\left[1 - \frac{V^2}{c_a^2}\right], \tag{14}$$

which is similar in form to Equation (6).

In order to integrate Equation (14) it is necessary to express the variable c_a in terms of V. Let c_1 be the acoustic velocity for an initial state of rest ($V_1 = 0$). Then $c_1^2 = kgp_1v_1$. Using this last relation, Equation (13), and the energy equation gives

$$c_a^2 = c_1^2 - \left(\frac{k-1}{2}\right) V^2. \tag{15}$$

The curve marked "adiabatic" in Fig. 1 is the type of curve obtained by substituting Equation (15) in Equation (14), and then integrating.

The maximum velocity reached in a converging tube for adiabatic flow is the acoustic velocity $\sqrt{kgRT}$. The maximum velocity reached in a converging tube for isothermal flow is $\sqrt{gRT}$. The acoustic velocity for the adiabatic process is higher than the acoustic velocity for the isothermal process. The adiabatic curve approaches an asymptote at a velocity above the acoustic velocity, as indicated by the vertical dotted line in Fig. 1. The isothermal curve does not reach any such asymptote.

For adiabatic flow the critical pressure ratio is given by the relation

$$\frac{p_c}{p_1} = \left(\frac{2}{k+1}\right)^{(k/k-1)}. \tag{16}$$

For air at normal conditions p_c/p_1 is about 0.53. This ratio is less than the corresponding ratio for isothermal flow.

ARMY AND NAVY NOTES.

The New Submachine Gun, M3.—COL. RENÉ R. STUDLER. (*Army Ordnance*, Vol. XXV, No. 140.) This new machine gun is the result of a system of planned experiment which had as its objective the solution of a specific problem in a minimum of time. After military requirements for a carbine were set up in May 1941, conditions were such as to prevent any usual methods for development and a free-for-all competition seemed to offer the most promise. By encouraging a number of commercial organizations to enter weapons in the contest, a maximum of talent was focused on the problem. By allowing each entrant to retain full patent rights, the prospective reward to the winner was very considerable. The competition method, while it did produce a satisfactory weapon in the required time, had several drawbacks. The amount of money and man-hours spent by all entrants was largely wasted and it required the foregoing of the opportunity of producing a surprise weapon.

The M3 submachine gun has, in numerous tests by the various service boards, proved to be superior to previous American-made submachine guns as well as to those of our allies and our enemies. It was produced under development contract and is a good example of the speed and efficiency of teamwork.

The need for such a weapon as the M3 was first foreseen in July 1942, when production capacity was inadequate for such weapons. What was required, in effect, was an improved gun that used neither the raw materials nor the machine tools normally required in gun manufacture. Within four months an experimental gun was available ready for test. It met the requirement and proved to be more accurate, easier to control, had less recoil, and a slower rate of fire which made each shot more effective.

The gun is all metal and uses the standard caliber .45 ball cartridge. A magazine feed of 30 shot capacity will fire at the rate of 450 rounds a minute. It employs the straight-blowback full-automatic principle. Single shots can be made by quick depression and release of the trigger. This is possible because of the slow motion of the bolt and the low rate of fire. The bolt has a fixed firing pin and is so designed that the excess energy from its forward motion is expended simultaneously with the explosion of the cartridge. This available energy is to counteract the muzzle rise in recoil of the weapon, thus improving accuracy of fire. The gun has an 8-inch barrel, a sliding removable stock, and weighs eight pounds.

When this new M3 was standardized, former standard submachine guns were classified as limited standard. It can be produced without complicated machine tools, and, since most of the components are made by the metal stamping process, many facilities equipped to do this type of work, which have been previously unable to take part in the war effort, can be utilized.

R. H. O.

NOTES FROM THE NATIONAL BUREAU OF STANDARDS.*

SOIL CORROSION OF PIPE LINES.

At the request of the water department of Wichita Falls, Texas, and with the coöperation of the Cast Iron Pipe Research Association, K. H. Logan, chief of the Bureau's underground corrosion section, is making a special survey of corrosion experienced in the vicinity of that city. The shortage of iron and steel has accentuated the need for reducing corrosion of pipe lines as much as possible. The most promising method at present seems to be the imposition of negative electrical potentials on a line which is to be protected. There are two ways of doing this, one by drawing energy from a regular power line, the other by connecting to the pipe line zinc slabs buried at intervals in the earth. The first method is in widespread use in Texas, and a very extensive installation of zinc anodes has been in use in southern Colorado for a number of years. The Petroleum Industry Electrical Association and a number of pipe-line organizations have asked for coöperation in determining the effectiveness of these two methods in the field and Mr. Logan will also consider this aspect of the problem.

PERFORATED COVER PLATES FOR STEEL COLUMNS.

An investigation of the characteristics of steel columns with perforated cover plates was started at the Bureau about two years ago, and some early results were given in Technical News Bulletin No. 382 (June, 1942). Progress reports in the *Journal of Research* have dealt with: The program and test methods (RP1473); Compressive properties of plates having ovaloid perforations of the following width-to-thickness ratios of—40 (RP1474), 68 (RP1501), and 53 (RP1514); Compressive properties of plates having circular perforations and a width-to-thickness ratio of 53 (RP1527); and Compressive properties of plates having a net-to-gross cross-sectional area ratio of 0.33 (RP1540).

The latest results of this work are reported by Martin Greenspan in the December *Journal of Research* (RP1568), in which he derives formulas for the over-all lengthening or shortening of a tension or compression member having a uniform gross cross section and a series of similar perforations of circular, elliptical, or ovaloid shape uniformly spaced along its length. Tests made on strips having circular perforations show that the applicable formula gives good results over the practical range of the variables.

* Communicated by the Director.

TEMPERATURE CONTROL EQUIPMENT.

Ordinarily temperature control equipment can be bought, but now it is necessary to improvise from units already at hand.

In certain work of the Bureau's fire resistance section it is necessary to control accurately the temperature of a piece of electrically heated equipment. The controlling thermocouple is connected in series with a potentiometer and a mirror-type galvanometer. The heating current is set at a value that would heat the equipment beyond the desired temperature if continuously applied. When its temperature goes beyond the desired limit, the potentiometer becomes unbalanced and the galvanometer reflects a beam of light on a photoelectric cell, the induced current in which is amplified in an electron tube to operate a telephone relay which in turn operates a relay in the power circuit. This introduces additional resistance into the power circuit, resulting in a lower temperature of the equipment controlled. When its temperature drops to the desired limit, the relays release and the higher heating current is on until the beginning of the next cycle. A temperature of 400° C. was maintained in one equipment within 1/100° C.

NEW ALTITUDE CHAMBER FOR TESTING AERONAUTICAL INSTRUMENTS.

Present day aerial warfare is carried on at very high altitudes. This has greatly increased the need for testing aircraft instruments and apparatus at temperatures and pressures encountered at altitudes above 30,000 feet. This is particularly true of apparatus for testing oxygen equipment, because at altitudes above 10,000 feet it is necessary that the pilots be supplied with oxygen, and their lives depend upon the reliable functioning of the controlling mechanism. To meet this need a new altitude chamber has been constructed at the Bureau. The chamber, which is cylindrical with a shallow dome at each end, is 78 inches in diameter by 116 inches high. It stands with the cylinder upright. A door opening 24 by 77 inches is provided. Three window ports and a tool lock are installed. The chamber is lined inside with 4 inches of cork for thermal insulation. This is necessary to enable the refrigeration unit to lower the temperature to − 50° C., a temperature which is not uncommon at the high altitudes at which fighting is now taking place. The pressure can be lowered by a vacuum pump far below the pressure at any altitude attainable by present airplanes.

BASIC IONIZATION CONSTANT AND pH VALUES OF METACRESOLSULFONPHTHALEIN.

A paper (RP1569) by Elizabeth E. Sager, Harry J. Keegan, and S. F. Acree, appearing in the December *Journal of Research*, reports a series of spectral transmittancy curves and the corresponding acidity

(pH values) obtained for the indicator metacresolsulfonphthalein in various solutions of acids and salts. Indicators are used for practical test and control of acidity and alkalinity in biological and industrial processes, and it is important to have accurate pH standards and methods for such purposes. The Bureau has in progress the selection and purification of indicators, acids, and salts suitable as "pH standards" and is determining their pH values at various temperatures. These compounds can be used for calibrating colorimetric and electrometric equipment, and for test and regulation of acidity in research laboratories, factories, or field stations.

Metacresolsulfonphthalein (1.25×10^{-5} M) in 0.001 to 1-M hydrochloric acid gives stable color standards varying from yellow to red, and their spectrophotometric absorption indices are useful in computing the pH values between 0 and 3.

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pH VALUES OF ACID-SALT MIXTURES.

A potentiometric method for determining whether or not the dissociation of strong acids or bases is essentially complete is described in a paper by Walter J. Hamer, Gladys D. Pinching, and S. F. Acree (RP1567) in the *Journal of Research* for December. The method is illustrated by data on p-phenolsulfonic and 4-chlorophenol-2-sulfonic acids. Measurements are made of the electromotive forces of hydrogen-silver-silver-chloride cells without liquid junction containing aqueous mixtures of the free acid and its sodium or potassium salts, to which known weights of potassium or sodium chloride have been added. The activity coefficients of hydrochloric acid in the mixtures are then calculated from the electromotive forces. The acid is completely dissociated into ions if the activity coefficients thus calculated are higher than those predicted by the limiting law of Debye and Hückel, and is incompletely dissociated if they are lower. By this criterion it was determined that the sulfonic acid groups of p-phenolsulfonic and 4-chlorophenol-2-sulfonic acids are completely dissociated into hydrogen and sulfonate ions.

Also given are the pH values of aqueous solutions of p-phenolsulfonic acid mixed with its sodium or potassium salt and sodium or potassium chloride, and of 4-chlorophenol-2-sulfonic acid mixed with its sodium salt and sodium chloride, for temperatures of 10°, 25°, 40°, and 60° C. The pH values of these solutions range from 1.2 to 2.6 and vary only slightly with changes in temperature; increasing at the rate of 0.00025 to 0.00045 pH unit per degree, depending upon the concentration of the solutions. They have a buffer capacity of approximately the same magnitude as mixtures of hydrochloric acid and sodium chloride. The solutions may be prepared from known weights of pure hydrochloric

acid and the dry salts recrystallized from distilled water. These solutions may be used for the accurate calibration of assemblies for determining the pH of solutions of high acidity, such as leather extracts, solutions of chromic acid, chrome tanning liquors, and lead storage battery fluids. They may also be used in the pH control of industrial processes, such as electroplating, that are carried out in solutions of high acidity.

The degree of dissociation of acidic and basic groups in indicators has a practical bearing on their use in determining the pH values of solutions.* As the sulfonic acid group is considered to be completely ionized, the color of a sulfonated indicator is independent of the degree of neutralization of this radical but not of weak phenolic and amino groups in the chromophores.

THE FRANKLIN INSTITUTE.

TENTH ANNIVERSARY CELEBRATION.
PRESENTATION OF VERMILYE MEDAL.

On Tuesday, November 9, The Franklin Institute celebrated the Tenth Anniversary of the opening of its new building on the Benjamin Franklin Parkway in Philadelphia.

At the same time the Vermilye Medal, awarded once every two years, was presented to Walter S. Gifford, President, American Telephone and Telegraph Company in New York City. This Medal is given "In recognition of outstanding contribution in the field of industrial management."

The program was divided into two parts.

FELS PLANETARIUM.

WAGNER SCHLESINGER, Presiding.

The opening of the Fels Planetarium was signalized by having Colonel Philip Fox, First Director of the Adler Planetarium in Chicago, the first in this country, give the Planetarium demonstration. Colonel Fox has been on active duty as Commanding Officer, Signal Corps Officers School, Army Electronics Training Center, Harvard University and Massachusetts Institute of Technology, Cambridge, Massachusetts. The meeting was presided over by Wagner Schlesinger, present Director of the Fels Planetarium. It was also addressed by James Stokley, General Electric Research Laboratories, who was the first Director of the Planetarium in Philadelphia.

After a short intermission, the guests reconvened in Franklin Hall, where Mr. Charles S. Redding, President of The Franklin Institute, called the meeting to order. The proceedings, with the papers in full, are given herewith:

MUSEUM.

CHARLES S. REDDING, President, Presiding.

Opening remarks: "It is with much pleasure that I bring to you the greetings of the Officers and Board of Managers of The Franklin Institute and extend to you a cordial welcome on the tenth anniversary of the opening of our Planetarium and Museum, both of which have afforded much pleasure and instruction to so many people.

In keeping with the war-time conditions under which we are now living, we are today combining in these unpretentious gatherings our anniversary celebration with the biennial award of the Vermilye Medal.

The simplicity of these exercises is not, however, in any sense a measure of the pride which we all feel in being associated with this great institution.

It *is* a great institution, with a long and honorable history—a history of accomplishment fully entitling The Franklin Institute to the new home in which it found itself ten years ago.

My part in this program is to preside and not to make a long speech, but I do want to take a moment or two to comment upon a very important subject, namely, the Institute staff—without which this building and what it contains would cease to function as a living institution. Forty-one members of our staff have been with us ten years or more and have served faithfully and well. We thank them, and also all those who have joined our staff more recently, for the fine work which has been and is being done.

I wish I could mention by name the forty-one in the ten year or longer group, but time does not permit.

I know, however, that we all want to pay our respects to our librarian, Walter Pertuch, who just recently celebrated the thirty-ninth anniversary of his association with the Institute. You will remember that in 1940 Mr. Pertuch succeeded his friend and teacher, Alfred Rigling, who passed away in that year after having served the Institute for fifty-seven years. This is the first official celebration of an anniversary in the Institute in the last fifty years held without the benign influence of Alfred Rigling. He had the deep satisfaction of seeing his beloved library properly housed before his death and if he were here now it would delight his heart to see how well his work is being continued by Walter Pertuch.

I think the other members of the staff will not be offended if I mention one more name—that of our gracious "Lady of the House," as she was referred to in a recent number of the *Institute News*—Miss Elizabeth D. Connelly. Since 1925 she has served us in many ways too numerous to mention and has proven invaluable in attending to the many details connected with the arranging of Institute gatherings including that in which we are now participating.

Again, my thanks, and I am sure, your thanks as well, to all those who under this roof are serving us so faithfully and so well.

There are so many phases of the Institute's activities about which I would like to speak—but I must again remind myself that I am only the presiding officer and that my job is to present to you the real speakers of the afternoon.

To a Philadelphia audience, George Wharton Pepper needs no introduction. He was one of the first to recognize the need for a Franklin Memorial in Philadelphia as a "new home," as he termed it, for Dr. Franklin, from which could be reincarnated the life, interests and homely virtues of that great American.

With Mr. Curtis, Mr. Pepper took hold, as chairman of the Campaign Funds Committee, of Benjamin Franklin Memorial, Inc.—the results we have been enjoying for these ten years.

For a number of years Mr. Pepper has been and still is an active and most helpful member of our Board of Managers, always stimulating us with his comments and suggestions. He was made an honorary member of the Institute in 1942. In 1938 he was the key speaker at the unveiling and dedication of the statue and memorial. Our great library reading room was dedicated as Pepper Hall in his honor.

In view of what he has done and is doing for The Franklin Institute, it is signally fitting that we should now be addressed by the Honorable George Wharton Pepper whose subject is "Then and Now." . . . Mr. Pepper."

THEN AND NOW.

By HONORABLE GEORGE WHARTON PEPPER.

"Then and Now" is a dangerous topic to assign to an elderly speaker. It tempts him to indulge in reminiscences of all sorts and to assert with tears in his voice that the world of today compares unfavorably with the world of long ago.

I am inclined to think, however, that the committee in charge of this ceremony felt safe in taking a chance on me. They knew that I am an incorrigible optimist: that I am ready to maintain that today is always better than yesterday, that tomorrow will be better than today and that the Golden Age is ahead of us and not behind. I refuse to be discouraged either by industrial unrest or by war. I concede that it takes a big bed to accommodate President Roosevelt, Mr. Churchill, Comrade Stalin and Generalissimo Chiang Kai-Shek; but it is a good sign that they are willing to bunk together and I wish them pleasant dreams. I insist that totalitarianism, or government by ruthless compulsion, is actually less effective—both in peace and war—than a system in which coöperation is voluntary and the citizen keeps a will of his own. "Muddling" may be a good word to describe the democratic process—provided we remember that the process muddles through. Totalitarianism never muddles; but because of fundamental weakness it is "through" long before its objective can be attained.

In the case of the Franklin Memorial the "Then" of which today we are thinking is a "Then" of only ten years ago. Now that we have the Museum and the Statue and the Memorial Building which houses them all it is difficult to visualize the situation as it was when these things were merely dreams. For a hundred and forty years Philadelphia had talked about Franklin and boasted of his achievements but had failed to erect to him a worthy shrine or to offer him a suitable home. We had passed through periods of prosperity when money-raising was relatively easy—but no disciple of Franklin had stepped forward to lead

the way. Then came the crash of October 1929—following national disregard of every one of Poor Richard's precepts. One would have expected that under such conditions the long-deferred memorial would be deferred still longer. Not so. Happily there were men among us who believed that the time to buy opportunity is when the market is cheap—and that the market is always cheapest when the days are evil. The men of the Poor Richard Club had sensed this truth even if they didn't know that in so doing they were accepting the teaching of St. Paul. The project of the Memorial was laid before Cyrus Curtis, another man of vision. He accepted it with enthusiasm and translated the dream into reality.

What do you know about the prophet Haggai? The 37th Book of the Bible is the only one that mentions him—and this merely gives us a glimpse of four months of his life. What did he do in that short time that secured him his place among the Immortals? He realized that his people could never regain the favor of the Lord and reacquire their one-time greatness unless and until they rebuilt the Temple and provided the Lord with a worthy shrine. The prophet accordingly approached the Governor of Judah and the High Priest with a stirring message. "People say," his message ran, "that this is not the right time to build the Lord's house—and yet these same objectors are well content themselves to live in their own comfortable houses and let the Lord's house lie waste." Then he exhorted them to hurry to the mountains and to the quarries in quest of timber and stone and resume the work of rebuilding without further delay. He so aroused the governor, the High Priest and all the people that within the month they actually began their great task. In the following month the prophet spoke words of encouragement to the workers and by the end of the fourth month such progress had been made that he assured the people of the blessing of God and proclaimed the Governor to be the Lord's chosen witness. We know no more of the prophet than this. He had done his work. The building was finished in four years' time.

This all happened nearly twenty-five hundred years ago; but the "Then" bears a striking resemblance to our "Then" of only a decade back. A recognized need. An unconscionable delay in meeting it. Popular objection that this was no time for a drive. Plenty of people with plenty of means—but quite content to spend it on themselves. Nothing doing for lack of a leader. Then Cyrus Curtis stepped forward—and the thing was done. Over $5,000,000 was pledged in twelve days by over eleven thousand subscribers. In the minds of readers of oriental history the name of "Cyrus" is associated with that of "Darius." Those of you interested in coincidences will note that it was in the time of our own Cyrus that the Memorial came into being and that it was in the second year of the reign of Darius that Haggai did his great work.

Many of us recall the incidents of that campaign which made 1930

memorable in the annals of Philadelphia. Some, like Leonard H. Kinnard, are happily still with us. We must never forget the debt of gratitude we owe to him. Others of the then leaders have passed on. Dr. McClenahan is among their number. His delightful personality made all our campaign meetings pleasant. His cheery smile relieved many tense situations. Some of you will remember the pleasure he took when later he visited Dr. von Miller at the Museum in Munich from which we had gained inspiration for our Memorial. With his portly figure, high forehead, and benevolent countenance he had some claim to a likeness to Poor Richard himself. Even so he was somewhat taken aback when on emerging from Dr. Miller's office he found himself confronted by a curious crowd. It then developed that a guide had passed the word around that the Museum was being honored by a visit from the great Dr. Franklin from Philadelphia whom all were eager to see.

So much for the "Then." All I need say about the "Now" is that it is the happy fulfillment of a dream. This fine building has become an integral part of the life of Philadelphia. It has compelled the designation of our great civic highway as the Benjamin Franklin Parkway. The Museum has proved to be what we planned it to become—not a mortuary exhibit of inanimate objects but an organism instinct with life. The great Planetarium has helped multitudes of people to realize that the heavens declare the glory of God and that the firmament showeth His handiwork. Dr. Franklin himself was quick to accept the tender of this permanent home. Here he is always to be found by eager pilgrims—present bodily in Franklin Hall while his spirit pervades the Museum. Hardly had he moved in when the war clouds gathered and presently broke. I thought then that his philosophic calm would be dispelled; but I have since imagined his satisfaction as the ever-increasing amount of important war work which is here being done under his auspices. It is not permissible to divulge details respecting this work. Suffice it to say that in its nature it corresponds with the scientific character of the Institute; that in value it is altogether worthy of the Franklin tradition; and that in volume it is an appreciable contribution to the winning of the war.

I cannot, in this brief address, do justice to the men and women whose effective efforts have bridged the gap between the Then and the Now. Sydney L. Wright has done this adequately in his story of The Franklin Institute. In 1935 the great Einstein made headlines at the Institute. Scheduled to speak on Medal Day over a coast to coast network, he stood in our lecture hall at the microphone and announced, "I have nothing to say!" Much publicity resulted. The newspapers heralded him as a very wise man who, having nothing to say, said nothing! You will all wish, as I do, that I were as wise as he! The Institute during the decade has been singularly fortunate in its executives. Nathan

Hayward and Philip Staples have earned for themselves a high place on our Roll of Honor. President Redding is proving himself their worthy successor. When Howard McClenahan died we were for a time at a loss to fill his place. Providentially Henry Allen proved available and now it is almost as hard to think of the Franklin Memorial without him as to conceive of Philadelphia without the Franklin Memorial.

When we are contrasting the "Then" and the "Now" it seems proper to individualize at least some of those to whom our progress is due. One of the three that I propose for official recognition is the man who first interpreted to America the immense possibilities of the Planetarium. Another is the man whose farseeing generosity gave our own Planetarium to Philadelphia. The third is a gracious lady who not only well represents her late father, the man who made the Memorial a reality, but is herself a patron of art and science and a citizen of whom Philadelphia is justly proud.

I suggest, Mr. President, that in the exercise of the authority vested in you by the Board of Managers you do now confer on each member of this distinguished trio proposed by the Board of Managers the certificate of honorary membership in The Franklin Institute to which they were unanimously elected by the Institute's membership.

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Accordingly, I present to you for this outstanding recognition Colonel Philip Fox, U. S. Army, Commanding Officer of the Signal Corps Officers School at Cambridge; our generous and highly esteemed patron, Samuel Fels; and our well-beloved fellow citizen, Mary Curtis Zimbalist.

The honorary memberships were bestowed as follows:

"To—Colonel Philip Fox, U.S.A., First Director, of first planetarium in this country—Adler in Chicago:

'In recognition of his development of the possibilities of the planetarium instrument in a manner calculated to popularize the science of astronomy.'

* * *

To—Samuel S. Fels, President, Fels and Company, member of the Board of Managers of The Franklin Institute, donor of the Fels Planetarium to the people of Philadelphia:

'In recognition of his deep abiding interest in his fellow man which caused him to visualize the importance of the planetarium as an instrument of instruction and recreation, and to order its importation to this country as a source of lasting benefit to the City of Philadelphia.'

* * *

To—Mary Curtis Zimbalist: 'patron of the arts and sciences, distinguished daughter of a distinguished father, who, by her devoted interest to The Franklin Institute has coöperated in making live in the present the high aspirations for the name of Franklin which her father venerated in the past.'"

* * *

PRESENTATION OF VERMILYE MEDAL.

Remarks by MR. REDDING, President.

"We now pass on to the second part of this portion of our exercises—the presentation of the Vermilye Medal. This medal was founded in 1937 by Mr. William M. Vermilye, Vice President of the National City Bank of New York, a close friend and ardent supporter of the Institute, and Chairman of our National Franklin Committee. Mr. Vermilye has at various times been associated with a number of industrial enterprises and has been a close student of management problems. This interest led him to endow the Vermilye Medal to be awarded by The Franklin Institute biennially in recognition of outstanding contribution in the field of Industrial Management.

This award has been made on two previous occasions: the first to Mr. Lewis H. Brown, of the Johns-Manville Company; and the second to Mr. William S. Knudsen, now General Knudsen.

The award of the Vermilye Medal is made by our Board of Managers on the recommendation of a committee of that Board known as the Vermilye Medal Committee. That committee comprises Messrs. Richard T. Nalle, Chairman, Philip C. Staples, Edward G. Budd, and Charles Penrose.

In arriving at its decision with respect to the award of the Vermilye Medal, the Vermilye Medal Committee is ably assisted by an advisory committee made up of nationally known men with wide acquaintance in the industrial field, representing the American Society of Mechanical Engineers, the Chamber of Commerce of the United States, and the National Association of Manufacturers, with four members at large. Those now comprising that committee are:

William L. Batt, Chairman
Charles E. Brinley
Thomas R. Jones
Walter D. Fuller
Alvin Dodd
W. Gibson Carey, Jr.
Charles E. Hook

We are very fortunate today in having Mr. Vermilye with us, and I am very happy to have the opportunity of presenting him at this time. . . . Mr. Vermilye.

Our next speaker, who will present the 1943 Vermilye Medalist, is well known to us all . . . Mr. Richard T. Nalle . . . Vice-President of the Disston Company, a Vice-President of The Franklin Institute which he serves faithfully and well, and Chairman of the Vermilye Medal Committee of the Board of Managers, which committee, with the assistance of the Advisory Committee, has performed such an intelligent job in selecting the Medalist for the 1943 Vermilye Medal award.

I take pleasure in presenting Mr. Richard T. Nalle."

PRESENTATION OF WALTER S. GIFFORD, PRESIDENT, AMERICAN TELEPHONE AND TELEGRAPH COMPANY, TO RECEIVE THE VERMILYE MEDAL.

By RICHARD T. NALLE,

Chairman, Vermilye Committee, Board of Managers of The Franklin Institute.

"I have the honor to present for the award of the Vermilye Medal of The Franklin Institute of Pennsylvania a gentleman who has for many years played an outstanding part in the business and public affairs of the country at large.

In time of war, when a man's accomplishments are necessarily appraised in terms of contribution to the successful outcome of our great national effort, it is appropriate to look back briefly into his career and determine some of the influences which have urged him on to the type of performance which has brought him outstandingly to the consideration of your Committee of Award.

To him, the prosecution of war by industrial forces is not a new consideration. As a young man, at the time of the first World War, he left his desk in the Bell Telephone System to serve as Supervising Director of the Committee on Industrial Preparedness of the Naval Consulting Board. Later, for two years until 1918, he served as Director of the most important Council of National Defense at Washington, and, in advance of the peace, was Secretary of the United States Representation on the Inter-Allied Munitions Council at Paris.

Such experience was bound not only to emphasize to him the opportunities for great national service in time of peril but also the satisfaction which derived from its performance by a man whose talents afford him such an opportunity.

At the conclusion of the war he returned to his desk in the Bell Telephone System. In 1925 he became its president. At the present time he has the responsibility for the administrative direction of a company which, with its subsidiaries, embraces an engineering and operating force of 357,000 men and women, a manufacturing organization of 85,000, and a research laboratory staff of 7,000.

He has continuously inspired his organization to interpret each daily task in terms of maximum contribution to the war effort. That or-

ganization has responded in splendid fashion to the enormously increased governmental and general public demand for telephone service during the past three years, despite very heavy curtailment of the metals and materials employed by it in the furnishing of its service, despite the transfer of 51,000 men and women to the armed forces (a large portion of whom have joined the Signal Corps of the U. S. Army), and despite a sharply limited enjoyment of priorities in its production of the instrumentalities of telephone service available to the general public. The Laboratories of his company are devoting themselves exclusively to the needs of the Army and the Navy of this country and its allies. All but a small fraction of the facilities of the manufacturing department of the Bell System are confined to the production of an amazing variety of modern tools of war involving the principles of electrical communication, detection, and direction.

Throughout, he has evidenced a type of leadership which gives maximum encouragement, on the part of his fellow workers, to pride in and devotion to a service which implements the war industry of every section of the country.

And I believe it is not unimportant that a man so engrossed should have found the hours and zeal requisite for service at various times in such capacities as Director of the President's Organization on Unemployment Relief, as a member of the Business Advisory Committee of the Department of Commerce, of the National Citizens' Committee on Mobilization for Human Needs, as Chairman of Greater New York Fund, member of the War Resources Board, Chairman of the Industry Advisory Committee of the Defense Communications Board, Chairman of the Community Service Society of New York, and as Honorary Chancellor, Overseer and Director of a number of Colleges, Universities and Foundations which are close to his heart.

That hurried description of his work—his good work—his hard work—is, I grant, imperfect. We rejoice that in our American scheme of things, from a modest beginning in a small New England city, a man can stand forth so conspicuously, meet his obligations of citizenship so fully and so modestly, and, when grave crisis comes, direct an enormously far-flung industrial organization with so great incisiveness, coolness, vision, and zeal as to afford us happy reminder that such organization and such management are the peculiar hall-marks of American industry.

Mr. President, I therefore present to you in recognition of outstanding contribution in the field of Industrial Management—

WALTER S. GIFFORD

President of the American Telephone and Telegraph Company, who throughout the past two years of war has directed the managerial affairs

of the Bell Telephone industry in such a way as to afford singular satisfaction to the users of the service, the employees of the organization, the owners of the property, and the public at large; admirably meeting a greatly increased demand for the telephone service in face of sharp limitation of priorities on materials and men, and devoting the entire resources of his company's research laboratories as well as the great part of its manufacturing establishment to the special requirements of the armed forces of this country and of its allies."

The President of the Institute then handed the Medal to Mr. Gifford: "By power vested in me as President of The Franklin Institute, I hand you herewith the Vermilye Medal, bestowed in recognition of your outstanding contribution in the field of industrial management."

Mr. Gifford's remarks in acceptance of the award appear on page 37 of this issue.

At the close of his talk, Mr. Redding expressed appreciation of the audience to Mr. Gifford for his inspiring address and welcomed him as a member of The Franklin Institute Medalists.

CLOSING REMARKS BY THE PRESIDENT.

"The afternoon's formal exercises are now concluded, but before adjourning the meeting, may I, on behalf of our Hostess Committee, under the chairmanship of Mrs. Geary, invite you to remain to meet Mr. Gifford, Colonel Fox, Mr. Fels, and Mrs. Zimbalist, in the foyer, and to meet one another around the tea table. And may I express to the Hostess Committee our appreciation for the part that that Committee has played in rounding out our program.

The meeting is adjourned."

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STATED MONTHLY MEETING, DECEMBER 15, 1943.

After the playing of the National Anthem, Mr. Charles S. Redding, President and Presiding Officer, called to order the stated monthly meeting of The Franklin Institute.

Upon motion, the minutes of the November meeting were approved as printed in the JOURNAL of The Franklin Institute for December.

Dr. Henry Butler Allen, the Secretary, was then called upon to make his report, which follows:

Addition to Memberships—

Sustaining	1
Active	74
Associate	25
Student	13
Library Sustaining	2
Total	115

The total membership is now 5,645.

He then called the attention of the members to the annual Christmas Week Lectures on the James Mapes Dodge Foundation and stated that tickets might be purchased at the Institute. The lecturer, Dr. Richard M. Sutton, Professor of Physics, Haverford College, has prepared three lectures entitled:

"The Long Arms of a Giant"
"The Sharp Eyes of a Giant"
"The Keen Ears of a Giant"

to be given at the Institute on December 28, 29 and 30.

Dr. Allen stated that in accordance with the By-Laws, nomination of officers and certain members of the Board of Managers was in order, and read Article IV, Section 4 of the By-Laws of The Franklin Institute.

In agreement with these regulations, the following names were submitted:

President
(to serve one year)

Charles S. Redding

Vice-Presidents
(to serve one year)

Walton Forstall
W. Chattin Wetherill
Samuel S. Fels
Richard W. Lloyd
Richard T. Nalle

Treasurer
(to serve one year)

M. M. Price

Members of the Board of Managers
(to serve three years)

G. H. Clamer
Clarence L. Jordan
Lionel F. Levy
Charles Penrose
James H. Robins
Philip C. Staples
Philip H. Ward, Jr.

(to serve one year)

Clarence Tolan, Jr.
William M. Vermilye

The Chairman then asked if there were any nominations from the floor.

No other names were presented, and upon motion, duly seconded, the nominations were declared closed.

The Chairman then introduced the speaker of the evening, Dr. Rupen Eksergian, E. G. Budd Manufacturing Co., who spoke "On Gyroscopic and Vibrational Motions." The lecture was attended by many students, in addition to members of the Institute, and the lecture was well received.

It was dismissed at 10:15 by a rising vote of thanks to the lecturer.

HENRY BUTLER ALLEN,
Secretary

NEW MEMBERS OF THE FRANKLIN INSTITUTE ELECTED, JUNE 1, 1943, TO NOVEMBER 1, 1943.

HONORARY MEMBERS.

Colonel Philip Fox, U. S. A.
Mr. Samuel S. Fels.
Mrs. Efrem Zimbalist.

SUSTAINING MEMBERS.

Mr. E. J. Breneman
Mr. B. F. Covington
Mr. Thomas R. Cunningham
Mr. A. J. Diletto
Mr. John A. Dimond
Mr. Freddy O. Edwards
Mr. W. H. Eisenman
Mr. Leonard Gutekunst
Mr. Robert H. Leach
Mr. L. Houston Maguire
Mr. Joseph P. McGee
Mr. Herman Ozlek

Mr. J. B. Park
Mr. Ernest Roth
Mr. I. Sabel
Mr. Frank Strick
Mr. Joseph H. Sykes
Mr. W. E. Wark, Jr.
Mr. Howard G. Zeyer

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Mr. Royal E. Beck
Mr. William A. Breisacher
Mr. R. Paul Burns
Mr. Raynor Craig
Mr. Charles J. Davis
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Mr. L. G. N. Elliott
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Mr. Fred Erfling
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Mr. Willard E. Ferrell
Mr. Louis Fisher
Mr. Howard B. Flounders
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Mr. Kurt R. W. Gaebel
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Mr. Walter B. Gibbons
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Mr. Paul G. Haak
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Mr. J. Henry Healy, Sr.
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Mr. Walter L. Wolf
Mr. C. Elmer Woolston
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Mr. Louis N. Ahlers
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Mr. Edward Schwartz
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Mr. Samuel Segal
Mr. Wayne Sensenig
Mr. Nicholas Serpentino
Mr. J. Leonard Sessler
Mr. S. L. Shanaman
Mr. Joseph R. Sharpe, Sr.

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Dr. John D. Shoptaugh
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Mr. T. P. Wright
Mr. John Wrightson
Mr. William Wustner
Mr. Joseph Wurzel
Mr. Frederick Wynkoop
Mr. Howard M. Ziegler
Mr. Charles A. Zimmerman

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Mr. Anders Henrik Bull
Dr. Arthur Graham Glasgow
Mr. D. C. Hastings
Mr. Winfield B. Heinz
Pvt. Earl A. Hollinger, Jr.
Mrs. Anna Johnson
Lt. Comdr. J. B. Knight, Jr.
Dr. William A. Mosher
Mr. E. H. Mueller
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Mr. Aubrey J. Raffalovitch
Mr. W. C. Rockefeller
Miss Rena R. Schack
Mr. H. Douglass Short
Mr. Herbert K. Weiss

NECROLOGY.

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Dr. John F. Stevens '30
Dr. Pieter Zeeman '25

Active Life Members.

Mr. Benjamin J. Dashiell '90
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Mr. B. W. MacDonald '42
Mr. William M. Potts '01
Mr. John H. Uhrig '39
Mr. Warren P. Valentine '27
Mr. J. D. Williamson, Jr. '85

Active Non-Resident.

Prof. Arthur W. Goodspeed '12
Mr. Howard L. Ingersoll '38
Dr. Elmer O. Kraemer '29
Dr. John M. Macfarlane '27

COMMITTEE ON SCIENCE AND THE ARTS.

(Abstract of Proceedings of Stated Meeting held Wednesday, December 8, 1943.)

HALL OF THE COMMITTEE,
PHILADELPHIA, DECEMBER 8, 1943.

DR. JOSEPH S. HEPBURN *in the Chair.*

The following report was presented for final action:

No. 3127: Henderson Medal.

This report recommended the award of the George R. Henderson Medal to Joseph Burroughs Ennis, of Paterson, New Jersey, "In consideration of his accomplishments in locomotive engineering and important contributions in the field of locomotive design."

JOHN FRAZER,
Secretary to Committee.

LIBRARY NOTES.

The Committee on Library desires to add to the collections any technical works that members would wish to contribute. Contributions will be gratefully acknowledged and placed in the library. Duplicates received will be transferred to other libraries as gifts of the donor.

Photostat prints of any material in the collections can be supplied on request. The average cost for a print 9 × 14 inches is thirty-five cents.

The library and reading room are open on Mondays, Tuesdays, Fridays and Saturdays from nine o'clock A.M. until five o'clock P.M., Wednesdays and Thursdays from two until ten o'clock P.M.

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NOTES FROM THE BIOCHEMICAL RESEARCH FOUNDATION.

The Preparation and Immunogenic Properties of an Ultraviolet-Inactivated Poliomyelitis Vaccine.—DONALD W. MCKINSTRY AND ELIZABETH H. READING. The preparation of safe and effective virus vaccines involves preservation in the immunizing agent of the maximum antigenicity compatible with safety from infection and toxic effects. It has recently been demonstrated with the viruses of influenza and rabies that this may be accomplished by the proper application of ultraviolet light (Salk, J. E., Lavin, G. I. and Francis, T., Jr., *Journal of Experimental Medicine*, **72**: 729, 1940; Hodes, H. L., Webster, L. T., and Lavin, G. I., *Journal of Experimental Medicine*, **72**: 437, 1940). Although previous investigators have shown that the virus of poliomyelitis is readily inactivated by this type of radiation (Jungeblut, C. W., *Proceedings of the Society for Experimental Biology and Medicine*, **37**: 160, 1937; Toomey, J. A., *American Journal of Diseases of Children*, **53**: 1490, 1937), immunization of experimental animals with such a preparation has not been reported.

This communication describes the preparation and immunogenic capacity of a safe and effective poliomyelitis vaccine inactivated by ultraviolet light of optimal intensity under controlled conditions.

The irradiated vaccine was prepared from the brain tissue of mice infected with the SK murine strain * of poliomyelitis virus in its 310th mouse passage. The brains of animals sacrificed during the paralytic stage were ground with sand and sufficient 0.85 per cent. saline to make a 10 per cent. suspension. After thorough homogenization and refrigeration overnight at 4° C., gross particulate matter was removed by centrifugation at 1,500 r.p.m. for 10 minutes. The opalescent supernatant fluid containing 100,000 intraperitoneal lethal doses per milliliter was carefully withdrawn for irradiation.

The source of ultraviolet radiation employed was the full light of an H-3, 85 watt mercury-arc lamp with a slit in the outer envelope to permit transmission of the maximum ultraviolet energy. A quartz lens 1½″ in diameter with a focal length of 4½″, placed 5½″ from the lamp, was employed for the purpose of focusing the light. Small quantities (1.0 ml.) of the virus suspension were subjected to irradiation in a small (1 cm. × 4 cm.) cylindrical quartz tube placed 1½″ from the lens. The intensity of ultraviolet light at this point was determined by means of a photoelectric tube, a reading of 53 microamperes being obtained after the lamp had been in operation for 30 minutes. The introduction of a Corning light filter No. 5970 into the system reduced the reading to

* We are indebted to Dr. Claus W. Jungeblut, College of Physicians and Surgeons, Columbia University, for the strain of virus employed in this study.

18 microamperes. The tube containing the virus suspension was rotated at high speed by means of a small electric motor in such a manner as to expose a thin film of the suspension to the action of the rays. Thorough mixing of the suspension was accomplished by breaking the circuit for short intervals during the irradiation period of 20 minutes.

Preliminary studies indicated that the virus is completely inactivated by irradiation under the conditions described for this period of time. Exposure for a significantly longer or shorter period invariably disturbs the balance between virulence and antigenic potency. Inactivation of the virus was determined by injecting small amounts (0.03 ml.) intracerebrally into each of a series of young mice.

Three groups of Swiss albino mice (10 to 15 g. body weight) were injected with small doses of the vaccine spaced over a period of two

TABLE I.

Immunizing Potency of Ultraviolet-Inactivated Poliomyelitis Vaccine.

Vaccination.				Challenge Dose of 1,000–10,000 M.L.D. Administered.	Number of Mice.	Mice Surviving 30 days.	
Route.	No. of Doses.	Amt. of Dose.	Total Amount.			Number.	Per cent.
		ml.	*ml.*				
Intraperitoneally	4	0.1 0.25 0.5 1.0	1.85	Intraperitoneally Intranasally	10 8	10 8	100 100
Subcutaneously	6	0.2	1.2	Intraperitoneally Intranasally	10 9	10 9	100 100
Intravenously	5	0.05	0.25	Intraperitoneally Intranasally	8 7	7 7	87.5 100
Virus Controls				Intraperitoneally Intranasally	24 21	0 0	0 0

weeks. The first group was vaccinated intraperitoneally; the second, subcutaneously; the third, intravenously. A fourth group was set aside to be used as controls. Approximately one week after administration of the last dose of vaccine, the immunity of the vaccinated mice was tested by injecting each of them with from 1,000 to 10,000 M.L.D. of the active virus. Each group was divided into two sub-groups: one group was challenged with virus administered intraperitoneally; the other with the challenge virus instilled intranasally. The challenge virus was titrated simultaneously by intraperitoneal and intranasal inoculation into normal mice of the same age as that of the vaccinated animals. The minimum lethal dose was considered to be the smallest amount which killed between 50 per cent. and 100 per cent. of the unvaccinated controls during the observation period of 30 days. The results are given in Table I.

Further immunization studies with monkeys are being conducted, and the results will be reported.

SUMMARY.

Details of the preparation and the immunogenic properties of an ultraviolet-inactivated poliomyelitis vaccine are described. The data presented indicate that the SK murine strain of the virus may be inactivated by controlled irradiation and yet retain sufficient immunizing potency to protect mice against 1,000 to 10,000 M.L.D. of the active virus administered intraperitoneally or intranasally.

Counterbalanced Plugs for the High Speed Angle Centrifuge.—H. M. TERRILL. The high speed angle centrifuge generally utilizes celluloid tubes to hold the material. These tubes are comparatively thin and if unsupported are liable to collapse, or even break up at extreme speeds.

Metal plugs are often inserted in the open ends of the tubes to support the celluloid, and plugs of various designs have been constructed

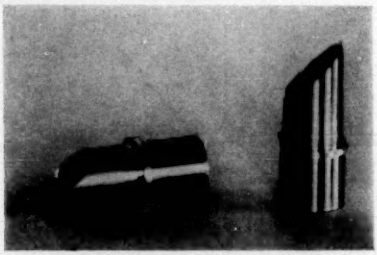

FIG. 1. Counterbalanced plugs of aluminum alloy.

by Beams (*Review of Scientific Instruments*, **9**: 248, 1938), Pickels (*Review of Scientific Instruments*, **13**: 101, 1942), Rosenfeld (*Review of Scientific Instruments*, **13**: 154, 1942), and others. Some of these designs, however, are quite complicated or difficult to manufacture, while others require the cells in the rotor to be threaded so that the plugs can be screwed in place.

The plugs described below are simple to make and do not require threading of the rotor cells. They support the celluloid adequately, and are regularly used in the centrifuge of the Biochemical Research Foundation whenever speeds in excess of 30,000 r.p.m. are required. They are suitable, however, only for centrifuges where the tubes are inclined at an angle of 45 degrees.

The plugs are made of aluminum alloy and are turned to fit the mouths of the tubes snugly, extending downward on the inner side to

support the wall. In order to reduce the weight as far as possible, they are made hollow, with a thin web in the center. The cross-section is shown in Fig. 2.

When in position in the rotor, the part *ACED* is within the celluloid tube, and the tube is oriented in the cell so that the side *AC* is toward the axis of rotation. The flange *CE* is cut away at *E* where the plug rests against the outer wall of the rotor above the cell.

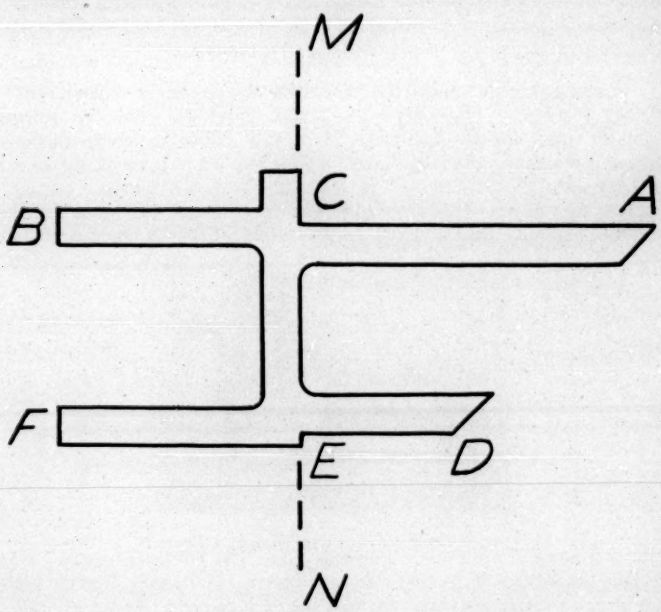

FIG. 2. Cross-section showing construction details.

The portion *BCEF* is the counterbalance. The plug should almost balance about the line *MN*, the counterbalance being slightly heavier. The counterbalance is an important feature of the design. When the centrifuge is running at high speed, the plug is acted upon by forces of considerable magnitude. Without the counterbalance the plug would tend to turn on the point *D* as a fulcrum, cutting into the wall of the tube. Furthermore, at extreme speeds, it might induce undesirable stresses in the body of the rotor. With the counterbalance, however, the plug will rest on the outer wall of the rotor along the line *EF*, there being no tendency to turn and no pressure on the celluloid tube.

When these plugs are used, it is essential that the celluloid tubes be cut to the same length as the rotor cells, so that they do not project beyond the cell walls. The amount of liquid in the tube is regulated so that none of it touches the plug when the rotor is up to speed, although the tip of the plug will just dip into the liquid when the rotor is at rest. In cases where this is undesirable, the extreme tip of the plug may be cut off, or the plugs may be cut at a smaller angle, or even square across. Plugs so cut will not protect the celluloid to quite as high speeds, but the difference is small.

Before these plugs were developed, considerable difficulty was experienced with the celluloid tubes at the Biochemical Research Foundation. At speeds approximating 27,000 r.p.m., the tops of the tubes folded over, and occasional breakages occurred. Above 35,000 r.p.m., the tubes collapsed badly, and breakages were frequent. Now, with the plugs in use, the tubes stand speeds of 40,000 r.p.m. without injury.

BOOK REVIEWS.

ENCYCLOPEDIA OF SUBSTITUTES AND SYNTHETICS, Edited by Morris D. Schoengold. 382 pages, 16 × 23 cms. New York, Philosophical Library, 1943, Price $10.00.

Mainly because of more-or-less temporary world conditions, economic conditions, and technologic progress, substitutes and synthetics have come to play an important part in the life of everyone. Change is the keynote of the times. Many industries are faced not only with a substitution of their product but with replacement of the very raw material from which it is made so that the business of seeking substitutes and synthetics is becoming very real. A quick means of doing this is via a good, up-to-date materials encyclopedia. The book at hand endeavors to fill this need.

Here there are listed alphabetically a great many materials. Both basic materials as well as substitutes and synthetics are covered. For instance take copper. First a brief description of it is given, its properties, solubilities and uses. Then substitutes for its many uses are given, including various plastics. Then looking under the plastics by name one is informed what they are, and their uses, etc. Or the book may be employed in a direct manner for synthetics or substitutes by name. In the back there is an index of trade names and a subject index.

The work is modern in every respect and should be very helpful in furnishing a fund of information.

R. H. OPPERMANN.

BIOCHEMISTRY OF THE FATTY ACIDS AND THEIR COMPOUNDS, THE LIPIDS, by W. R. Bloor. American Chemical Society Monograph Series, Number 93. 387 pages, tables and illustrations, 16 × 23 cms. New York, Reinhold Publishing Company, 1943. Price $6.00.

Fatty substances are one group of organic substances which go to make up plant and animal tissues. The chemical entity characterizing fatty substances is the fatty acid, the members of which group are either actually or potentially compounds of the fatty acids. The most recent term proposed for this group is "lipid" (or "lipide") and the group is characterized generally in insolubility in water and solubility in "fat solvents," e.g., ether, chloroform, benzene, etc. At the present time much interest is exhibited in these substances by biochemists and it is recognized that they take a part in living structures and processes second only to proteins.

This American Chemical Society Monograph is timely and it should provide a valuable background to further and quicken the desired knowledge of this important subject. It begins with descriptive and analytical chemistry, first classifying the lipids, then giving methods of examination of tissue lipids. Following this is a discussion of the voluminous literature on the digestion and absorption of neutral fats (triglycerides of the higher fatty acids). There is included here a discussion of other lipids on which, however, relatively little work has been done. Chapter three is devoted to lipids of blood. Here at the beginning is pointed out the difference between blood and the fixed or solid tissues having a larger proportion of tissue fluid. In many animals a large proportion of the cells or corpuscles have no nuclei, which undoubtedly limits their "vital" activity.

Lipids in tissues is the next chapter heading. In this are included muscle, brain and nervous system, nature and function of tissue lipids, lipids of plants, and lipids of microorganisms. Probably the most interesting part of the book, to many, is that on lipid metabolism. Less is known about this than the other great groups of substances, partly because there has been less effort expended on them and partly because they are inherently difficult to approach. The last chapter, on the lipids of secretions and excretions, is a discussion of the

lipids in the variety of liquids and solids which are produced by the tissues of living organisms and removed from the cells producing them.

The book represents an exhaustive summary of this great field as it is today. It is built from many, many literature sources which are carefully and expertly placed together in an orderly arrangement, producing a valuable source of information. It is indeed a stepping stone in the furtherance of knowledge.

R. H. OPPERMANN.

ADVANCED QUANTITATIVE ANALYSIS, A Companion Volume to Elementary Quantitative Analysis, by Hobart H. Willard, Ph.D., and Harvey Diehl, Ph.D. 457 pages, illustrations, 15 × 22 cms. New York, D. Van Nostrand Company, Inc., 1943. Price $4.75.

There are two things which a successful analyst must possess. The first is that he should have an understanding of the entire method of analysis. The second is that he know the chemistry involved and all that relates to it. A worker who has only number one, and follows a written procedure may develop skill in manipulation but will never become a chemist. The authors of this text state that methods of analysis used in the courses for which this text is designed are typical ones which illustrate general principles and techniques. These may be applied to other cases than the ones studied, but this requires a complete knowledge of the reactions and principles involved. Therefore emphasis is laid on the latter.

This book is a companion volume to "Elementary Quantitative Analysis," by Willard, and Furman. As such, the treatment of certain subjects is supplementary in nature rather than complete. Roughly, the work may be divided into three parts. At the outset certain general instructions are given to students with regard to laboratory work. This is followed by explanations of general operations of quantitative analysis such as sampling, the preparation and weighing of samples, the methods of concentrating small amounts of materials, and down through extraction methods, electrodeposition to the methods of reporting analytical results.

The second part of the book is devoted to the analysis of iron ore, steel and silicate rock and has sections devoted to the analytical chemistry of each of the elements encountered. Directions for laboratory work accompany this portion of the book. The last part of the book is a discussion of the analytical chemistry of each of the elements not studied earlier; the common and most of the rarer elements are treated. Sufficient information is given to supply the student with the basic knowledge needed for solving the problems involved in the analysis of complex inorganic mixtures. Lastly there is a discussion on the different methods of determining atomic weights. In the back there is a subject as well as an author index. Throughout the work a great many references are given.

It is very apparent that this text is the result of much experience in teaching as well as a thorough knowledge of the subject. It is of value as a text and as a reference work.

R. H. OPPERMANN.

PATENT LAW, for Chemists, Engineers and Students, by Chester H. Biesterfeld. 225 pages, 14 × 22 cms. New York, John Wiley & Sons, Inc.; London, Chapman and Hall, Limited, 1943. Price $2.75.

The United States patent system allowing all persons free scope for their inventive faculties has been the chief motive force for the development of the industrial arts. That it has been and is a powerful force is plainly evident. The patent statute like all other statutes has undergone considerable change in its interpretation through the years. During the past five or ten years, for instance it is noticeable from a reading of many court decisions, that the judges have been influenced by a number of changing industrial and economic conditions, with the result that a materially higher standard of invention has been followed in many cases. The result has been that a large percentage of patents has been invalidated in the various circuits. It is very important therefore, that engineers and scientists who are in any way interested in patent law, become familiar with the latest understanding of the basic principles.

This book is designed especially to present various subjects of the law in the light of present practice. After a brief introduction the subject of invention and discovery is taken up.

This is followed in order by a consideration of the various ways in which a patent or the application therefore may be invalidated or anticipated on the ground of lack of novelty; priority of invention; originality; questions of breadth and scope of chemical claims that are so drawn as to cover groups or families of chemical compounds or substances; functional claims, wherein it is noted that there is no set form of words that confers functionality upon a claim; the large class of inventions involving the use of a machine or article or composition of matter; double patenting; reissues; disclaimers; patent application and prosecution; interferences; infringement; liability for infringement; the various incidents of licenses; ownership and shoprights; trade secrets; principal features of patent litigation and searches.

The author continually refers to various decisions, of which there are a large number, to illustrate present day opinion. In the back of the book there is a table of cases and a subject index. The work is a combination of good presentation, an expert knowledge of the subject, and an exhaustive search for pertinent cases which were analyzed and classified.

R. H. OPPERMANN.

GENERAL PHYSICS, a Textbook for Colleges, by Oswald Blackwood, Ph.D. 622 pages, diagrams and illustrations, 14 × 22 cms. New York, John Wiley & Sons, Inc.; London, Chapman & Hall, Limited, 1943. Price $3.75.

Much attention and thought has been given in recent years toward a more effective presentation of physics in the classroom. As a result a great deal of drudgery has been removed and a higher percentage of students survive. There is still room for improvement however and the book at hand is a late model of injecting interest via cleverly using practical every-day illustrations of things which are of common interest. Thus, in the beginning on the subject of mechanics the author has dealt with the motions and energies of bodies large enough to be seen—with baseballs, cannonballs and automobiles. There are considered some of the fundamental laws of physics, among which is the conservation of energy and of momentum.

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Following this, in the usual order, molecular physics and heat are taken up, dealing with particles too small to be glimpsed even through the most powerful microscope. This is in contrast to the earlier part of the book. Here too, the idea of every-day illustrations is used. They include the coffee perculator, the steam engine, the expansion of milk in a bottle by freezing etc. Picking up the threads of the several types of motion previously considered, the reader is introduced at this point to the study of the to-and-fro or vibrating type of motion—more complex types, but fundamental to an understanding of sound, light, radio and other kinds of waves. This, logically leads to the study of light and later, electricity and magnetism. The latter is quite detailed for a general course in physics, especially the chapters on alternating currents, and on radio. The alternating current chapter, it is stated, may be omitted if desired.

A feature of the book is the last part, devoted to an explanation of the new physics. Here ions and electronics, x-ray and photoelectricity, radioactivity and cosmic rays, and the emission and absorption of light are discovered. At the outset, any misconception that the new physics replaces the old is dispelled, and it is pointed out that some of the old laws are not valid in describing the behavior of extremely small particles such as atoms and electrons.

For a college course in general physics, this text is excellent. It is flexible in the way that its construction permits omissions of certain chapters to accommodate a short course. There is a summary at the end of each chapter, brief and so broad as to avoid its use in place of the text proper. Then come review questions and problems arranged in the order of difficulty. At the end of the book in the appendices of very useful information, are supplementary problems for each chapter and the answers to all problems in the book are there listed. This latter greatly increases the scope of usefulness of the book to include that great mass of students who must necessarily study entirely or partially at home.

R. H. OPPERMANN.

ELECTRICAL ENGINEERING, Basic Analysis, by Everett M. Strong. 391 pages, charts and illustrations, 15 × 22 cms. New York, John Wiley and Sons, Inc.; London, Chapman and Hall, Limited, 1943. Price $4.00.

All too often there is found a widespread misconception that the study of engineering involves primarily the memorizing of formulas which engineers use, and practice of their application until the student is proficient enough to hold a job. In this sense, the engineer is a kind of formula technician or recipe operator. To be a successful engineer, of course, requires a quite different concept, and the course which provides a professional training to qualify an engineer as a creator rather than merely a user of formulas is the course worth while.

The text on hand on electrical engineering has attached to its title "Basic Analysis." This is indicative that stress is laid on the development of analytical study habits, a natural tendency to analyze a situation into basic components which are known. Designed for college use, it depends upon prerequisites of mathematics through calculus and one year of physics. The sequence and content are somewhat at variance with the usual work of this kind. It opens with an introduction, speaking generally at first, then proceeding to electrical topics. Here the student is early made acquainted with the author's style—a frank, to-the-point and friendly discussion, carefully adding encouragement.

Subsequent chapter headings show the path of study. They are, in order, electric current and conductors, electrical measuring instruments, measurement of resistance, electromotive force, electromagnetic induction, alternating E.M.F., electric power circuits, electrical networks, varying resistivity and non-uniform section of conductors, magnetics, magnetic circuits, magnetic force-electromagnets, inductance, circuits with resistance and inductance, electrostatics, circuits with resistance and capacitance, and finally series circuits with R. L. and C. Thus it is seen that there is little resemblance in progression with older introductions to electrical engineering.

One place in the work illustrative of the up-to-dateness as well as of the definiteness with which the material is presented is that devoted to electrostatics. It is pointed out here that in the light of present knowledge, incomplete as it is, there is reasonable evidence that the condenser concept is erroneous, that no electric charge is stored in the Leyden jar. And further—no change occurs in the amount of the electron content of a capacitor. Later it is clearly stated that the charging of a capacitor does deliver to the capacitor a charge of energy.

References are listed at the end of each chapter for further study. Likewise there are numerous questions and problems covering all subject matter. Appendix I gives useful tabular information and in Appendix II determinants for algebra are given. A very practical coverage concerning computation in engineering, including the use of the slide rule, is given in Appendix III. There is a subject index in the back, after which appear a number of detachable work sheets among which are certain graphs to save the student time for copying them from the text.

This text certainly deserves the attention of instructors, students including home-study students, and practicing engineers for refresher study and reference.

R. H. OPPERMANN.

VEGETABLE FATS AND OILS, second edition, by George S. Jamieson, Ph.D. 508 pages, tables, 16 × 23 cms. New York, Reinhold Publishing Corporation, 1943. Price $6.75.

One of the reasons why there is great demand for some substances is because much is known about them. Included in this is the orderly arrangement of the classes of each subject from its derivation or extraction through its uses, to its disposal or consumption. The American Chemical Society by means of the monographs has done much in this direction. The book at hand is a good illustration, it being in its second edition. It reflects added knowledge as well as new practices.

A general treatment on fats and oils opens the work covering their distribution, formation, utilization and composition. Other topics here are extraction and refining, solvents, nutritive value, rancidity and emulsions. Then the fats and oils are divided into three classes and each is taken up separately. The first is non-drying fats and oils. This is followed by semi-

drying oils and finally drying oils. The non-drying class contains those products having iodine numbers up to 100; the second class contains those having iodine numbers from 100 to 130; and the third or drying class of oils has an iodine number of 130 or more. Whenever feasible, the fats or oils from plants of the same family are grouped together. The division of each class contains in order the name of the fat or oil and a good summary of its properties, etc.

The fatty acids are covered in another division of the book which is followed by procedures that may be used for the preparation of samples in quantities sufficient for examination or experimental purposes. Standard procedure for determinations or tests is then given. This completes the book proper. There follow two appendices, one giving information on the character of oils from the seeds of ornamental and other trees and plants. The other appendix contains tables of useful information of various kinds. At the end there is an index of botanical names, and a subject index.

The book contains a great deal of useable information, arranged so that it can easily be obtained. The many references to the literature are listed so that the reader can distinguish those having direct bearing and those useful to broaden knowledge. This edition is destined to be as much help as the first edition to all those interested in the subject.

R. H. OPPERMANN.

PUBLICATIONS RECEIVED.

Lubrication of Industrial and Marine Machinery, by William Gordon Forbes. 319 pages, illustrations and charts, 14 × 22 cms. New York, John Wiley & Sons, Inc., Chapman & Hall, Limited., 1943. Price $3.50.

Lubricants and Cutting Oils for Machine Tools, by William Gordon Forbes. 90 pages, tables, diagrams and illustrations, 14 × 22 cms. New York, John Wiley & Sons, Inc., Chapman & Hall, Limited, 1943. Price $1.50.

Basic Aircraft Construction, by Ross A. Peterson and Raymond E. Erickson. 204 pages, illustrations and diagrams, 13 × 19 cms. New York, Prentice-Hall, Inc., 1943. Price $2.00.

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CURRENT TOPICS.

ARMY AND NAVY NOTES.

Redesigning the Machine-Gun Mount by the Industry-Ordnance Team.—MAJOR C. D. ALDERMAN. (*Mechanical Engineering*, Vol. 65, No. 9.) Early in the war it became increasingly evident that the caliber .50 antiaircraft machine gun had a job to do and was doing the job. However, the pre-Pearl Harbor model was job-shop design and was difficult, and the Ordnance Department was getting only about 3600 per month from six plants because of the machine operations involved and the bronze, aluminum, alloy steel, and special parts required in the mount.

A Philadelphia manufacturing plant undertook the problem of designing a caliber .50 machine gun mount that would conserve critical materials and the critical machine hours and, more important, that could be made by mass production methods. With true American industry point of view, they also tackled the problem of the handling, transportation, and operation of the weapon.

The result was a gun mount on which the production in one plant almost doubled the total previously made in six plants, and, more important, a gun which was a better offensive and defensive weapon by Army standards.

The new gun mount could fire at any angle from horizontal to vertical and this without the gunner's being a contortionist, because at any angle he could maintain an erect position. It could be raised or lowered or swung from side to side with ease. It was more accurate against fast-moving targets. There was no complicated sight to interfere with field of vision. There was armor plate protection for the gunner. A man can operate this new gun for hours at a time whereas the old one had him completely worn out after a two-hour wrestle.

Taking into consideration that this is a mobile war, this gun mount was so designed that it breaks down quickly into serviceably light man loads that can be transported by plane, truck, or hand. By the addition of quick moving clamps, it is possible to remove the mount from its fixed position or replace it in a matter of seconds without the use of tools. By the addition of a pedestal-base adapter, the gun can be used on boats, trucks, land, or buildings.

The new design eliminates all bronze, aluminum, and alloy steels in the mount. Even the added armor plate is nickel-free, low-alloy. Seventy-five per cent. of the forgings and castings were eliminated. Standard stock, sheet, plate, and bar are used in fabrication. All parts, such as pipe, nuts, bolts, bearings, and the like, are standard and easily obtainable.

R. H. O.

Individual Tracer Control.—MAJOR GEORGE W. RACE. (*Coast Artillery Journal*, Vol. LXXXVI, No. 4.) The author gives some very practical information for the use of antiaircraft machine gunners in connection with which some general information is of interest.

Individual tracer control is defined as a system of machine gun fire control whereby the individual gunner places his fire on the target as a result of his own observation of the tracer stream. In its pure form it takes no cognizance of the presence of sights on the machine gun. Firing must be continuous in order to provide an unbroken tracer stream; interruption of the tracer stream (firing in bursts) is destructive to this form of fire control due to the fact that in such case the gunner must begin his adjustment all over again at the beginning of each burst. Efficient observation of the tracer stream is tremendously hampered by two factors; first, the total absence of depth perception ability (stereoscopic vision) at ranges exceeding 300 yards, and secondly, the curve, both real and apparent, of the tracer stream in space.

Sterescopic vision is actually only one of the several factors in depth perception and depends entirely on the angle subtended by the distance between the eyes. At about 500 yards range, this angle becomes so small as to be useless; consequently, at longer ranges the relative position of objects is unconsciously determined by other factors, as comparative sizes, superimposition, amount of visible detail, etc. From this standpoint it would become necessary to compare the tracer and the airplane target, as seen together, in order to determine which was at the longer range, or to become more exact, in order to pick up a point on the tracer's path having the same range as the airplane. This is obviously impossible; even at very short ranges it is doubtful whether or not depth perception is effective when applied to a source of light having neither sharp outline nor definite shape.

If the tracer stream were laterally straight in appearance the limitations of depth perception would have little effect on the problem, it being then necessary only to pass the line of the tracers through the target. Unfortunately however, the tracer stream presents a definitely curved appearance both in lateral and vertical plane.

The vertical curve of the tracer stream is a real curve. It is due to the actual gravity drop of the projectile below the line of fire.

The lateral curve of the tracer stream is both real and fictitious. The real element of the curve is produced by the traverse of the gun during firing. Tracers fired successively with a constantly changing azimuth are viewed simultaneously, each individual tracer being at a different range and azimuth from the others being viewed; thus by polar coordinates an actual curve is plotted in the sky.

The fictitious element of a lateral curve is produced by motion of the target; the target in space is the reference point upon which the eyes are focused, consequently the target appears stationary, its lateral motion manifesting itself as lateral motion of the individual tracers in rearward direction.

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